MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 93 No. 4

1933 FEBRUARY 10

ANNUAL GENERAL MEETING

Dr. H. Knox-Shaw, President, in the Chair.

The Minutes of the preceding Annual General Meeting were read and confirmed.

The President announced that Dr. V. M. Slipher would deliver the George Darwin Lecture at an Ordinary Meeting of the Society, the date to be announced later.

The Annual Report of the Council was partly read.

The Report of the Auditors of the Treasurer's accounts for the year 1932 was read, and is given on p. 219.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year. The names of those elected are given on p. 318.

The following Amendments to the Bye-laws, which were proposed by the Council, and of which due notice had been given to the Fellows, were put to the Meeting :—

(1) That the following be substituted for Bye-law 6—

"A newly elected Council shall contain at least four Fellows not serving as officers or otherwise on the previous Council."

(2) That the following passage be removed from Bye-law 9—

"Such list to contain the names of at least four Fellows not serving in any capacity on the existing Council."

(3) That the following be substituted for Bye-law 29—

"The election of Associates shall rest with the Council."

The following amendment to (1) was proposed by Major A. E. Levin, seconded by Dr. G. Merton, and was adopted :—

That the following be substituted for Bye-law 6—

"A newly elected Council shall contain at least four Fellows who have not served as officers or otherwise on the retiring Council."

Amendment No. (1) as amended was carried.
Amendments Nos. (2) and (3) were carried.

The President delivered an Address on The Distances and Motions of the Extra-Galactic Nebulæ (see p. 304).

Dr. Smart described the Cambridge Photo-electric Photometer.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's accounts and to the Scrutineers of the ballot.

The election by the Council of the following Fellows was duly confirmed :—

Stanley M. Ballance, A.R.P.S., F.R.Met.Soc., 3 Westfield Avenue, Harpenden, Herts ;
James Blackhall, Woodlands, Hythe, Hants ; and
F. O'B. Ellison, Principal of the Government Medical College, Colombo, Ceylon.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

Samuel Alfred Barrett, F.R.G.S., B.S., M.S., Ph.D., Sc.D., Director of Milwaukee Public Museum, Wisconsin, U.S.A. (proposed by B. R. Baumgardt) ;
Vernon Brown, Wing Commander, R.A.F., M.A., A.F.R.Aë.S., Eversley, Sollershott West, Letchworth, Herts (proposed by W. M. Smart) ;
George Douglas Buchanan, Nether Kirkton, Neilston, Renfrewshire, Scotland (proposed by James Knight) ;
Herbert Frank Finch, Royal Observatory, Greenwich, London, S.E. 10 (proposed by F. W. Dyson) ;
Walter James Langford, M.Sc., B.Sc., Senior Mathematical Master, Bec School, Tooting, S.W. 17, 12 Stratton Road, Merton Park, London, S.W. 19 (proposed by E. H. Neville) ;
Henri Mineur, D.-ès-Sc., Astronome à l'Observatoire de Paris, 16 Avenue Trudaine, Paris 9, France (proposed by A. de la Baume Pluvinel) ; and
Andrew David Thackeray, B.A., King's College, Cambridge (proposed by J. Evershed).

The following election, announced 1932 May 13, is void :—

Maurice Rupert Meehan, The High School, Marlborough, Wilts.

REPORT OF THE COUNCIL TO THE HUNDRED AND THIRTEENTH ANNUAL GENERAL MEETING OF THE SOCIETY.

PROGRESS AND PRESENT STATE OF THE SOCIETY

	Patron	Institutional Members	Honorary Member	Fellows		Associates	Total
				Compounders	Annual Subscribers		
1931 December 31	1	3	1	216	710	45	976
Since elected	...	+1	...	+1	+34	+5	...
Deceased	...	...	...	−6	−11	−3	...
Resigned	...	...	...	...	−21	...	...
Since compounded	...	...	...	+5	− 5	...	...
Removed from list	...	...	...	...	−15	...	...
1932 December 31	1	4	1	216	692	47	961

(Six Associates are also Fellows, and are therefore counted twice in the above table.)

Cash

RECEIVED

	£ s. d.	£ s. d.
Balances, 1932 January 1 :—		
In hand of Assistant Secretary on Petty Cash Account	12 5 8	
At Bankers', on Current Account	313 1 3	
At Bankers', on Deposit Account	675 10 7	
At Bankers', on "C" Account (Trust Funds)	111 2 11	
Cheque not yet credited	2 2 0	
		1114 2 5
Received on account of Dividends :—		
£1250 Metropolitan Consolidated 3% Stock	37 10 0	
£2000 Swansea Corporation 3½% Stock	70 0 0	
£2287, 6*s.* 9*d.* East India Railway 3% Debenture Stock	51 9 0	
£5125 London, Midland and Scottish Railway 4% Debenture Stock	151 3 9	
£750 London, Midland and Scottish Railway 4% Consolidated Preference Stock	16 10 0	
£2400 Gas Light & Coke Co. 3% Debenture Stock	53 2 0	
£2000 Commercial Gas Co. 3% Debenture Stock	45 0 0	
£4877, 12*s.* 6*d.* War Loan Inscribed 5% Stock (half-year's Dividend)	121 18 9	
£695, 16*s.* 0*d.* Conversion Loan 3½% Stock, 1961	24 7 0	
£419, 17*s.* 11*d.* Conversion Loan 4½% Stock, 1940–44	18 17 10	
£700 Birmingham Corporation 3% Inscribed Stock (half-year's Dividend)	7 17 6	
£496 Consolidated Loan 4% (half-year's Dividend)	7 8 9	
£1035 Agricultural Mortgage 4½% Debenture Stock (half-year's Dividend)	17 9 4	
£500 New South Wales 4% Stock, 1942–62 (half-year's Dividend)	7 10 0	
Interest on Deposit Account	13 5 11	
Income Tax refunded, 1931 April–1932 April	108 18 3	
	752 8 1	
Sales of Publications £319 16 3		
Reprints 79 12 7		
	399 8 10	
Sales of Photographs	48 8 0	
Miscellaneous Receipts :—		
London Mathematical Society, expenses of Meetings, etc. £30 0 0		
Assistant Secretary and Clerk, Pension Premiums ... 19 5 0		
Postages repaid 4 6 1		
Use of Telephone 0 10 11		
Excess on Subscriptions 3 10 0		
Donation to General Fund 1 1 0		
Sales of Baily's Portrait 1 0 0		
Sale of Clock Case 2 0 0		
	61 13 0	
		1261 17 11
Proceeds of Sale of £6812, 2*s.* 8*d.* War Loan 5% (General and Trust Funds)		6943 14 5
Bequest from the late Mr. A. F. Lindemann		1000 0 0
Received on account of Subscriptions :—		
575 Annual Contributions (including 3 Institutional Membership fees)	1207 10 0	
24 Annual Contributions 1933 in advance (including 1 Institutional Membership fee)	50 8 0	
1 Annual Contribution 1934 in advance	2 2 0	
37 Admission Fees (including 3 due in 1931)	77 14 0	
36 First Contributions (including 3 due in 1931)	70 7 0	
Arrears paid off :—		
6 for 1930 ... ... £12 12 0		
27 for 1931 ... ... 56 14 0		
	69 6 0	
		1477 7 0
Compositions		103 19 0
Trust Fund Dividends :—		
£1212, 13*s.* 3*d.* East Indian Railway 3% Stock	27 6 0	
£542, 18*s.* 2*d.* India 3½% Stock	19 0 0	
£1934, 10*s.* 2*d.* 5% War Stock, 1929–47 (half-year's Dividend) ...	48 7 3	
£965 Agricultural Mortgage 4½% Stock (half-year's Dividend) ...	16 5 9	
£1004 Consolidated Loan 4% (half-year's Dividend)	15 1 3	
Donation from General Fund (balance of George Darwin Lecture fee)	0 11 10	
Income Tax refunded, 1931 April–1932 April	9 1 10	
		135 13 11

Examined and found correct.
(Signed) W. M. WITCHELL.
H. W. NEWTON.

1933 *January* 13.

£12,036 14 8

Account

PAID

	£ s. d.	£ s. d.
Assistant Secretary : Salary...	250 0 0	
Clerk : Salary...	175 0 0	
Assistant Secretary and Clerk for work done for London Mathematical Society in 1931	10 0 0	
Pension Premiums for Assistant Secretary and Clerk	57 15 0	
Porter and Wife : Wages	156 11 0	
Health and Unemployment Insurance	7 2 7	
		656 8 7
Licence for Porter	0 15 0	
Fire and Accident Insurance	15 15 3	
Telephone	14 4 5	
Telegraphic Address and Time Signal	7 2 8	
Water Rate	12 12 0	
		50 9 4
Postage and Packing (including postage of *Monthly Notices*, etc., £125, 11s. 7d.)		181 17 8
Printing, etc. :—		
Monthly Notices (Vol. **92**, Nos. 1–8)...	1154 8 9	
Geophysical Supplements (Vol. **3**, Nos. 1, 2)	162 15 0	
Reprints	141 18 3	
Miscellaneous	62 1 4	
Photo-engraving :—		
Monthly Notices £73 5 7		
Geophysical Supplements 14 5 1		
	87 10 8	
		1608 14 0
Reproduction of Photographs for sale		75 1 0
Stationery and Office Expenses	27 5 5	
Library : Equipment, Binding and Purchase of Books (General Fund)	20 11 7	
Subscription to International Telegrams Bureau	6 5 11	
Subscription to Committee on Library Co-operation	1 1 0	
Coal, Gas, Electric Light, Firewood	103 15 6	
House Expenses and Laundry	20 16 8	
Fittings and Repairs	30 14 8	
Balance of George Darwin Lecture Fee	0 11 10	
Miscellaneous Expenditure	15 5 6	
Officers' Travelling Expenses	5 17 6	
Expenses of R.A.S. Meetings and Committees	18 16 6	
Expenses of Geophysical Meetings	5 18 3	
Expenses of L.M.S. Meetings	6 1 10	
Bank Charges and Cheque-Books	2 12 0	
		265 14 2
Office of Works, re-wiring Society's premises		185 0 0
		3023 4 9
Purchase of £700 Birmingham Corporation 3% Stock, 1947	506 14 6	
Purchase of £1500 Consolidated Loan 4% (General and Trust Funds)	1505 16 6	
Purchase of £2000 Agricultural Mortgage Corporation 4½% Debenture Stock, 1961–91 (General, Special and Trust Funds)...	2000 4 0	
Purchase of £2000 New Zealand Loan, 1940 3½%	1570 4 0	
Purchase of £1000 Hull Corporation 4½% Stock, 1952–72	1013 18 0	
Purchase of £1000 Central Electricity Board 4½% Stock, 1957–82 ...	968 4 6	
	7565 1 6	
Purchase of £500 War Loan 3½% Stock ... ... } Lindemann	500 1 0	
Purchase of £500 New South Wales 4% Stock, 1942–62 } Bequest	501 6 0	
		8566 8 6
Expenditure on Trust Accounts :—		
George Darwin Lecture Fee	50 0 0	
Turnor and Horrocks Fund (Library)...	16 10 10	
Harry Watson Fund (Library)...	53 19 0	
Lee and Janson Fund	10 0 0	
		130 9 10
Balances, 1932 December 31 :—		
In hand of Assistant Secretary on Petty Cash Account	10 9 9	
At Bankers', on Current Account	189 14 10	
At Bankers', on " C " Account (Trust Funds)	116 7 0	
		316 11 7
		£12,036 14 8

Revenue

	£	s.	d.	£	s.	d.
To General Expenditure as per Cash Account	3023	4	9			
,, Reserve for Accounts due but not presented...	390	0	0			
	3413	4	9			
Less Reserve for Accounts due 1931 now written back ...	200	0	0			
				3213	4	9
,, Amount transferred to Composition Fees Reserve Fund in 1932...				103	19	0
,, 32 Annual Contributions in Arrear written off	69	6	0			
,, 22 Annual Contributions 1932 written off as per contra ...	46	4	0			
				115	10	0
				£3432	13	9

Examined and found correct.

(Signed) W. M. WITCHELL.
H. W. NEWTON.

1933 *January* 13.

Account, 1932

		£ s. d.	£ s. d.
By Subscriptions—			
575	Annual Contributions 1932, including 3 Institutional Membership Fees	1207 10 0	
30	ditto paid in 1931, now matured	63 0 0	
70	ditto, outstanding	147 0 0	
22	Contributions for 1932 due, but unpaid, in respect of Fellows died, resigned, or names removed, and written off per contra	46 4 0	
			1463 14 0
,, 31	First Contributions, 1932, at 2 guineas	65 2 0	
2	ditto, at 1 guinea	2 2 0	
1	ditto, at 2 guineas, outstanding	2 2 0	
34			69 6 0
,, 34	Admission Fees, 1932	71 8 0	
1	ditto, outstanding	2 2 0	
35			73 10 0
,, 1	Composition Fee at 30 guineas	31 10 0	
5	ditto, reduced	72 9 0	
6			103 19 0
,,	6% of Composition Fees Reserve Fund as per Balance Sheet, transferred to Current Revenue		30 19 11
,,	Sundry Debtors, 1932		8 15 7
,,	Dividends, Sales of Publications and Photographs, and Miscellaneous Receipts, as per Cash Account	1261 17 11	
Less	Payments due 1930	1 19 0	
	Payments due 1931	24 5 9	
	Advance payments for *Monthly Notices*, Vol. 93	59 12 9	
	Overpayment on publications, 1932	0 11 0	
	Income Tax (General Fund) 1931 April–December, refunded in 1932	62 8 2	
		148 16 8	
			1113 1 3
,,	Payments for *Monthly Notices*, Vol. 92, received in 1931 and now matured		74 11 6
,,	Income Tax (General Fund) deducted at source 1932 April–December, not yet refunded		75 6 5
	Excess of Expenditure over Income, 1932		419 10 1
			£3432 13 9

Balance Sheet

LIABILITIES

	£ s. d.	£ s. d.
3 Subscriptions for 1933–35, paid in 1931	6 6 0	
24 Subscriptions for 1933, paid in 1932	50 8 0	
1 Subscription for 1934, paid in 1932	2 2 0	
		58 16 0
Sundry Creditors for Accounts due but not presented ...		390 0 0
Cash Balances (Income) of Trust Funds—		
Turnor and Horrocks Fund	4 10 3	
Harry Watson Fund	51 12 2	
Lee and Janson Fund	16 10 2	
Hannah Jackson Fund	28 13 2	
George Darwin Lectureship Fund	15 1 3	
		116 7 0
Trust Funds (Capital), as at 1931 December 31	2949 17 0	
Profit on sale of War Loan...	14 3 0	
		2964 0 0
Income Tax on Trust Funds, 1932 April–December, not yet refunded, as per contra		12 4 9
Special Fund (Capital), as at 1931 December 31	1457 6 5	
Profit on sale of War Loan...	2 13 7	
		1460 0 0
Composition Fees Reserve Fund—		
As at 1931 December 31	412 12 5	
Received in 1932	103 19 0	
	516 11 5	
Less 6% transferred to current revenue	30 19 11	
		485 11 6
Advance payments for *Monthly Notices*, Vol. 93		59 12 9
Credits for overpayments on publications, 1931 and 1932 ...		1 8 11
General Fund—		
As at 1931 December 31	16,033 16 7	
Add Profit on sale of War Loan (General Fund) ...	74 17 5	
Add Lindemann Bequest	1000 0 0	
	17,108 14 0	
Deduct Excess of Expenditure over Income, 1932 ...	419 10 1	
		16,689 3 11
		£22,237 4 10

Examined and found correct.

(Signed) W. M. WITCHELL.
H. W. NEWTON.

1933 *January* 13.

1932 *December* 31

ASSETS

	£ s. d.	£ s. d.
Sundry Debtors for Subscriptions in Arrears—		
27 for 1931	56 14 0	
70 for 1932	147 0 0	
1 Admission Fee, 1932, outstanding	2 2 0	
1 First Contribution, 1932, outstanding	2 2 0	
		207 18 0
Sundry Debtors, 1932—		
Due for Publications and Reprints	7 9 7	
Due for Photographs	0 15 0	
Due for Postages	0 11 0	
		8 15 7
Investments of General Fund—		
(1) Investments, other than War Loan, at 1922 valuation	11,134 0 0	
(2) New Investments, 1932, valued at cost—		
(*a*) From proceeds of sale of War Loan—		
£496 Consolidated Loan 4% ... £497 16 6		
£500 Agricultural Mortgage 4½% ... 500 4 0		
£1000 Hull Corporation 4½% ... 1013 18 0		
£1000 Central Electricity Board 4½% 968 4 6		
£2000 New Zealand Loan, 1940 3½% 1570 4 0		
	4550 7 0	
(*b*) From Cash Balance on deposit—		
£700 Birmingham Corporation 3%	506 14 6	
(*c*) From Lindemann Bequest—		
£500 War Loan 3½% 500 1 0		
£500 New South Wales 4%, 1942–62 501 6 0		
	1001 7 0	
		17,192 8 6
Investments of Special Fund—		
(1) Investments in Conversion Loans, valued at cost ...	925 0 0	
(2) New Investment, 1932 (from proceeds of sale of War Loan) valued at cost—		
£535 Agricultural Mortgage 4½%	535 0 0	
		1460 0 0
Investments of Trust Funds—		
(1) Investments in East Indian Railway and India 3½%, at 1922 valuation	991 0 0	
(2) New Investments, 1932 (from proceeds of sale of War Loan), valued at cost—		
£1004 Consolidated Loan 4%... ... £1008 0 0		
£965 Agricultural Mortgage 4½% ... 965 0 0		
	1973 0 0	
		2964 0 0
Income Tax 1932 April–December, deducted at source and not yet refunded—		
General Fund	75 6 5	
Trust Funds	12 4 9	
		87 11 2
Sundry Balances—		
In hand of Assistant Secretary on Petty Cash Account ...	10 9 9	
At Bankers', on Current Account	189 14 10	
At Bankers', on " C " Account (Trust Funds)	116 7 0	
		316 11 7
		£22,237 4 10

Astronomical and other Manuscripts, Books, Prints, Photographs and Instruments.
Furniture, etc.
Stock of Publications and Photographs for sale.
Three Gold Medals.
Four Bronze (Jackson-Gwilt) Medals.
} Not valued.

* The Stock Exchange valuation of the investments on 1932 December 22 was £24,544 as compared with £21,616, 8*s.* 6*d.*, the value shown above. J. H. R.

INVESTMENTS

As at 1932 December 31

General Fund

£1250 Metropolitan 3-per-cent. Stock, 1941.
£2000 Swansea Corporation 3½-per-cent. Irredeemable Stock.
£2287, 6*s.* 9*d.* East Indian Railway 3-per-cent. New Debenture Stock.*
£5125 London, Midland, and Scottish Railway 4-per-cent. Debenture Stock.*
£750 London, Midland, and Scottish Railway 4-per-cent. Consolidated Preference Stock.*
£2400 Gas Light and Coke Co. 3-per-cent. Debenture Stock.*
£2000 Commercial Gas Co. 3-per-cent. Debenture Stock.*
£496 Consolidated 4-per-cent. Loan, 1967.
£500 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*
£1000 Hull Corporation 4½-per-cent. Redeemable Stock, 1952–72.*
£1000 Central Electricity Board 4½-per-cent. Stock, 1957–82.*
£2000 New Zealand 3½-per-cent. Loan, 1940.*
£700 Birmingham Corporation 3-per-cent. Inscribed Stock, 1947.*
£500 War Loan 3½-per-cent. Inscribed Stock.
£500 New South Wales 4-per-cent. Stock, 1942–62.*

Grove-Hills Special Fund

£419, 17*s.* 11*d.* Conversion Loan 4½-per-cent., 1940–44.
£695, 16*s.* 0*d.* Conversion Loan 3½-per-cent., 1961.
£535 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

Five Trust Funds

£1212, 13*s.* 3*d.* East Indian Railway 3-per-cent. Stock.*
£542, 18*s.* 2*d.* India 3½-per-cent. Stock.
£1004 Consolidated 4-per-cent. Loan, 1967.
£965 Agricultural Mortgage Corporation, Ltd., 4½-per-cent. Debenture Stock, 1961–91.*

* Taxed at source.

REPORT OF THE AUDITORS FOR THE YEAR 1932

We have examined the Treasurer's account of receipts and expenditure, and the Revenue Account and Balance Sheet, for the calendar year 1932, and have certified them to be correct. The investment holdings have been certified either by the Bank of England or by the Westminster Bank, and are in accordance with the printed list.

The sum held to reserve in respect of the liability of the Society to Fellows who have compounded is now £485, an increase of £73 during the year.

It will be seen that the expenditure on printing *Monthly Notices*, **92**, has remained at a figure approximately twenty-five per cent. higher than the average for the period 1921–30.

As regards the Revenue Account, the sum written down as reserve for accounts due but not yet presented includes the cost of the supplementary number of *Monthly Notices* (**92**, No. 9) issued in October. The sum appears to be a very close estimate of the amount required.

It will be noticed that the excess of expenditure over income is about £420. This comparatively large excess is due in great part to the cost of compulsory alterations to the wiring system for the electric lighting of the Society's premises, while contributory causes were a serious fall in the number of new Fellows elected during the year, and the considerable sum which has been written off in respect of subscription arrears. The necessity for expenditure on electric wiring arose in connection with a change in the electric supply from direct to alternating current, and will not recur. The diminution in the revenue from subscriptions is doubtless due to the general financial stringency of the times. It should be mentioned, too, that some loss in revenue has been incurred by reason of the decrease in the rate of interest obtainable from "gilt edged" investments. A reduction of approximately £35 in a full year will result from this circumstance. The loss would have been still greater if the Society's holding in 5 per cent. War Loan had not been exchanged, opportunely, for other securities, yielding indeed a somewhat lower rate than 5 per cent., but a rate which is substantially higher than that now payable on War Loan. The Deposit Account has been closed as being less remunerative than permanent investment of the floating balance. Temporary overdrafts may occasionally be necessary to meet current expenditure when current income is insufficient.

The bequest of £1000 made to the Society by the late Mr. A. F. Lindemann was received during the year and has been invested as shown in the Cash Account.

A list has been laid on the table containing the names of those Fellows who are in arrear for sums due on 1932 January 1, with the amount due against each Fellow's name.

The books, instruments and other effects on the premises appear to be in satisfactory order. It has been reported to us, however, that two books are missing from the library (in addition to the seven specified in the Auditors' Report for 1930) and cannot be accounted for. The titles of the books are :

Lick Observatory Bulletin, vol. viii.
Star-lore for Teachers, by Lowerison.

The Society is indebted to Mr. J. J. Hall for the gift of a marine chronometer (Arnold No. 548, with Airy's compensation).

We have much pleasure in acknowledging the ready help we have received from the Assistant Secretary both in explanation of details and in the general facilities given us during the audit.

(Signed) W. M. Witchell.
H. W. Newton.

1933 *January* 21

GIFTS TO THE GENERAL FUNDS AND PROPERTY OF THE SOCIETY

The John Lee Gift : In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell ; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were repurchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856) : Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876) : R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

The Lambert Bequest (1877) : C. J. Lambert, Esq., presented to the Society the sum of £500, free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905) : Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

The Farrar Bequest (1906) : The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Parsons Gift (1922) : The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock 1929–47, in memory of his father, the 3rd Earl of Rosse, who made the 6-foot reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922) : Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection

of early astronomical and mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Lindemann Bequest (1931): A. F. Lindemann, Esq., bequeathed to the Society the sum of £1000, free of legacy duty.

THE GROVE-HILLS SPECIAL FUND

In 1923 the Treasurer, Col. Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. The total amount received from all sources (including dividends on the investments representing the fund) has been £1913, 1*s.* 11*d.*, of which £1480, 2*s.* 10*d.* has been invested and is now represented by £535 Agricultural Mortgage 4½ per cent., £419, 17*s.* 11*d.* Conversion Loan 4½ per cent. 1940–44, and £695, 16*s.* Conversion Loan 3½ per cent. 1961.

TRUST FUNDS

The Lee and Janson Fund: In 1834 John Lee, Esq., LL.D., gave £100, and in 1876 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £334, 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock.

	£	*s.*	*d.*		£	*s.*	*d.*
1932 Jan. 1. Balance of Fund	16	9	6	1932. Grant from Fund ...	10	0	0
1932. Dividends, East Indian Railway ...	7	10	8	1932 Dec. 31. Balance of Fund	16	10	2
Income Tax, 1931 April–1932 April, refunded ...	2	10	0				
	£26	10	2		£26	10	2

The Turnor Fund and the Horrocks Memorial Fund: In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £464, 18*s.* East Indian Railway 3-per-cent. Debenture Stock. In 1876 the Society received a sum of £38, 15*s.*, the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks: to this the Society added the sum of £55, 15*s.*, and the whole now stands in £103, 6*s.* East Indian Railway 3-per-cent. Debenture Stock. The interest on these funds is to be used in the purchase of books for the library.

	£	s.	d.		£	s.	d.
1932 Jan. 1. Balance of Fund	4	0	2	1932. Purchase of Books ...	16	10	10
1932. Dividends, East Indian Railway ...	12	15	8	1932 Dec. 31. Balance of Fund	4	10	3
Income Tax, 1931 April–1932 April, refunded ...	4	5	3				
	£21	1	1		£21	1	1

The Harry Watson Memorial Fund : In 1920 Mrs. Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the library, such books to be indicated by a special book-plate. This gift now stands invested in £542, 18*s.* 2*d.* India 3½-per-cent. stock. In 1923 Mrs. Watson bequeathed a further sum of £958, 17*s.* 0*d.* to the Society, which now stands invested in £965 Agricultural Mortgage 4½-per-cent. Stock. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The Harry Watson Memorial Fund*, to be used for the purchase and binding of books.

	£	s.	d.		£	s.	d.
1932 Jan. 1. Balance of Fund	46	12	3	1932. Purchase of Books ...	21	2	6
1932. Dividends, India 3½ per cent.	19	0	0	Binding	32	16	6
Dividends, War Stock 5 per cent. (half year's dividend)	23	13	2	Purchase of £965 Agricultural Mortgage 4½ per cent. Stock	965	0	0
Sale of £946, 6*s.* 11*d.* War Stock 5 per cent. 1929–1947	965	0	0	1932 Dec. 31. Balance of Fund	51	12	2
Dividends, Agricultural Mortgage 4½ per cent. (half year's dividend) ...	16	5	9				
	£1070	11	2		£1070	11	2

The Hannah Jackson (née Gwilt) Fund : In 1861 Mrs. Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £309, 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock ; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£	s.	d.		£	s.	d.
1932 Jan. 1. Balance of Fund	19	6	11	1932 Dec. 31. Balance of Fund	28	13	2
1932. Dividends, East Indian Railway ...	6	19	8				
Income Tax, 1931 April–1932 April, refunded ...	2	6	7				
	£28	13	2		£28	13	2

The George Darwin Lectureship Fund : In 1926 June, the then President, Dr. J. H. Jeans, presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum was invested in £988, 3*s*. 3*d*. 5-per-cent. War Stock 1929–47 and has been re-invested this year in £1004 Consolidated 4-per-cent. Loan. The income is annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

	£	*s*.	*d*.		£	*s*.	*d*.
1932 Jan. 1. Balance of Fund	24	14	1	1932 May. Lecture Fee ...	50	0	0
1932. Dividends, War Stock 5 per cent (half year's dividend) ...	24	14	1	1932. Purchase of £1004 Consolidated 4 per cent. Loan	1008	0	0
Sale of £988, 3*s*. 3*d*. War Stock 5 per cent. ...	1008	0	0	1932 Dec. 31. Balance of Fund	15	1	3
Dividends, Consolidated 4 per cent. Loan (half year's dividend) ...	15	1	3				
Donation from General Fund	0	11	10				
	£1073	1	3		£1073	1	3

CELESTIAL PHOTOGRAPHS

The following have been added to the list of Celestial Photographs reproduced by the Society for sale to Fellows :—

R.A.S.
Ref. No.

430. Meteor Trail and Pleiades. 1932 Jan. 11. Lockyer.
431. Nebula M 8, N.G.C. 6523. 1919 June 27. Mount Wilson.
432. Nebula M 16, N.G.C. 6611. 1919 Aug. 25–26. Mount Wilson.
433. Cluster in Sagittarius, M 22. 1918 Aug. 6. Mount Wilson.
434. Comet Brooks. 1911 Oct. 25. Helwan.
435. Comet Brooks. 1911 Nov. 2. Helwan.
436. Comet Brooks. 1911 Nov. 4. Helwan.
437. Nebula N.G.C. 4361. 1912 May 14. Helwan.
438. Nebula N.G.C. 7293. 1910 Nov. 1, 2. Helwan.
439. Nebula N.G.C. 6729. Showing variability, 1913–16. Helwan.
440. Nebula in Orion, in extreme red and violet light. Lick.
441. Krueger 60. 1908 July 21 ; 1915 Sept. 22 ; 1920 July 10. Barnard, Yerkes.
442. 40-inch Refractor, Yerkes Observatory.
443. Spectra of ζ UMa. Spectroscopic binary, showing lines doubled. Yerkes Observatory.
444. Spectra of μ Orionis. Spectroscopic binary, showing variable displacement. Yerkes.

R.A.S.
Ref. No.

445. Sunspot. 1926 Sept. 18, 20. 9-inch and 4-inch photoheliographs. R.O. Greenwich.
446. Sun, 1928 Sept. 25, 27. 4-inch photoheliograph. R.O. Greenwich. (Slide.)
446A. Sun, 1928 Sept. 25. 4-inch photoheliograph. R.O. Greenwich. (Print.)
446B. Sun, 1928 Sept. 27. 4-inch photoheliograph. R.O. Greenwich. (Print.)
447. Sunspot, 1926 Jan. 20. 4-inch photoheliograph. R.O. Greenwich.
448. Transit of Mercury, 1914 Nov. 7. 4-inch photoheliograph. R.O. Greenwich.
449. Nebular Spectra, showing red shift increasing with distance. Humason, Mt. Wilson.
450. Solar Corona, 1930 Oct. 21. Ap. 4 in. F.L. 19 ft. Exp. 15 sec. Adams, Niuafo'ou.
451. Spectrum of Chromosphere, 1932 Aug. 31. 7-in. prismatic camera. Greenwich. Parent, Canada.
452. 60-in. Reflector, Mt. Wilson Observatory. F.L. 25 ft.
453. 36-in. Refractor, Lick Observatory. F.L. 57 ft. 10 in.

PUBLICATIONS OF THE SOCIETY

During the past year the Society has published *Monthly Notices*, vol. 92 ; and *Geophysical Supplements*, vol. 3, Nos. 1, 2.

OBITUARY

The Council regret that they have to record the loss by death of the following Fellows and Associates during the past year :—

Fellows :—William Briggs
Alexander Burton-Brown
John Charles Clancey
Charles Gaskell Falkner
William du Gard Gray
Walter Heath
Francisca Herschel
*George Hooper
Rhishard Llewelyn Jones
Cyrus Augustus Macfarlane
Donald Maclean
Neal McNeill
John Mastin
Frederick William Nash
Samuel Okell
Monroe B. Snyder
Edward Weldon
Edward Turner Whitelow

Associates :—Guillaume Bigourdan
Gustave Ferrié
Max Wolf

WILLIAM BRIGGS, who died on June 19 last at the age of seventy, is to be remembered as the originator of a system of teaching by correspondence, largely in connection with the examinations for degrees of the University of London, that has achieved much success. In the years 1883 to 1887, when engaged at St. Benedict's College, Fort Augustus, in Scotland, he inaugurated a system of this kind, and in the latter year removed to Cambridge, where he established the headquarters of the venture under the name of the University Correspondence College. He later founded the University Tutorial College, which was an organisation of classes for personal instruction in London. He had been a student at the Yorkshire College—now Leeds University—but entered at Jesus College, Cambridge, in 1888. He qualified for his degrees in the Mathematical Tripos of 1890 and in the Law Tripos of 1891, and was later awarded the degree of Doctorate of Law for a work on the law of copyright. The tuition scheme prospered exceedingly, and in connection with it he initiated the preparation and publication of many textbooks that developed into the University Tutorial

* Died 1931. Death not notified till 1932.

Press in London, which has its own printing and bookbinding works at Foxton, near Cambridge, where Dr. Briggs took a close personal interest in the welfare of the village. He was a generous benefactor to Jesus College and founded a Trust for helping undergraduates of the College who required financial help to continue their education. He was a prominent Freemason and was a Past Grand Treasurer of England. Direct connections with astronomy that may be mentioned are that he was a member of the large party that made the voyage to Vadsö, Norway, to see the eclipse of the Sun in 1896, and an excellent treatise on Mathematical Astronomy by Barlow and Bryan was written at his instigation.

He joined the Society on 1894 January 12.

H. P. H.

ALEXANDER BURTON-BROWN was born on 1840 September 8. He entered the Royal Military Academy in 1858 December, and this proved to be the prelude to a successful career as a soldier. He was promoted Captain, R.A., in 1872, Major in 1880, Lieut.-Colonel in 1886 and Colonel in 1890. Between the last two dates he had served in command of the Royal Artillery in the Straits Settlements, and in that capacity he had completed the re-armament of Singapore.

His scientific activities included the writing of a paper, "On the Geology of Gibraltar, with especial reference to the Recently Explored Caves of Bone Breccia." This was published in 1867. In 1864 he had joined the Geological Society, and he was elected a Fellow of the Royal Astronomical Society in the following year.

The *Monthly Notices* for 1895 January contained a paper by Burton-Brown entitled "Notes on Suitable Stations in Norway for Viewing the Total Eclipse of the Sun on 1896 August 8." He had, in fact, devoted a summer holiday in Norway to the task of collecting information. On the occasion of a subsequent eclipse, that of 1900 May 28, he was the leader of one of the British Astronomical Association parties which encamped on Cemetery Hill, above Algiers. During the totality Burton-Brown took charge of a camera obscura formed by projecting a $3\frac{1}{2}$-inch image of the Sun on a ground-glass screen, an equatorially mounted telescope being employed for the purpose. He obtained by this method an enlarged view of the corona, and his observations and the drawing which he made are published in E. W. Maunder's book *The Total Solar Eclipse of* 1900.

About twenty-three years ago Colonel Burton-Brown settled in Hastings, and he lived there until shortly before his death, which took place on 1932 January 28.

JOHN CHARLES CLANCEY was born at Agra on 1854 September 17. He was the son of T. J. Clancey, who was a civilian in the service of the Honourable East India Company and who was killed in Lucknow in 1857 on the occasion of the defence of the Residency. Clancey received his early education at St. George's College, Meisnoor House, Mussoorie, and subsequently proceeded to the Royal College of Science, South Kensington.

From 1872 to 1879 he was an Assistant Surveyor in the Great Trigonometrical Survey of India. After the Occupation of Upper Burma his services were requisitioned for the purpose of organising Survey Schools in that State. He established several such and instructed hundreds of lads who were set to work in the field with compass and theodolite. His services in connection with the Land Surveys were highly appreciated by the Government of Burma and were retained for a period of five years beyond the normal age of retirement. He retired in 1913, being at that time Assistant Director of Land Records. In 1912 he was decorated with the Imperial Service Order.

Mr. Clancey was the author of several books, some of which were printed in Burmese as well as English. Mention may be made here of *Aids to Land Surveying* and *Simplified Stellar Maps and Aspects of the Night Sky*.

During the early days of the Great War he sustained the loss of his only son who was killed in 1914 August. After the Armistice Clancey left England and returned to India where he joined the Third Order of St. Francis. He died at Agra in 1932 August.

He was elected a Fellow of the Society on 1897 February 12.

CHARLES GASKELL FALKNER was born at Dorchester on 1864 February 8. He was educated at Weymouth College, from whence he proceeded to Trinity College, Cambridge. After obtaining first-class honours in the Natural Science Tripos he was appointed Assistant Master at his old school, where he remained until 1901. He then left Weymouth to take up an appointment as Secretary to Sir W. G. Armstrong Whitworth & Co. at Openshaw, Manchester, a position which he held until 1926.

In 1903 he married Miss E. M. Sanders. He died at Weymouth on 1932 September 15, and is survived by five children.

He was elected a Fellow of the Society on 1908 April 10.

MAJOR-GENERAL WILLIAM DU GARD GRAY was born on 1856 September 9. He was the son of the late W. H. Gray of Ryde, Isle of Wight. He entered the Army in 1875 and served for part of his time in India with the 4th Battalion, The Punjab Infantry. He was later on the Staff, Bengal Army, and commanded the 55th Coke's Rifles, Frontier Force. He was promoted Major-General in 1906, and in 1908 was Inspector-General of Volunteers in India. His share in active service included service in the Kabul campaign, 1880–81; Takht-i-Suliman, 1883; Black Mountain, 1888; the Miranzai expeditions, 1891; Waziristan, 1894–95; N.W. Frontier, 1897; and the Mahsud Waziri Blockade, 1901–2. He was several times mentioned in dispatches. His commands in India included the Bannu, Multan, Jhelum, and Kohat brigades. He married, first, in 1894, Helen, daughter of Major J. Hawkins; and secondly, in 1915, Beatrice (who died in 1929), daughter of the late David Andrews. He was made C.B. in 1904. Major-General Gray was deeply interested in astronomy and spectroscopy, and was occupied as voluntary assistant to Professor A. Fowler from the beginning of 1914 to 1915 February, when he left to take

up war work. He especially assisted in experiments on the band spectrum of helium.

He died on 1932 June 2.

He was elected a Fellow of the Society on 1914 May 8.

WALTER HEATH, the younger son of the Rev. John Moore Heath, Vicar of Enfield, Middlesex, was born on 1855 May 11, and at the age of twelve went to Westminster School, as his father and brother had before him. After a successful school career he was awarded exhibitions tenable at Trinity College, Cambridge, on leaving in the spring of 1873, but did not proceed to the University until the following year. He obtained a Trinity scholarship in 1877 and took his degree as twenty-third wrangler in the Mathematical Tripos of 1878. After a short period during which he was an assistant master at Tonbridge School, he qualified as a solicitor and practised at Brisbane, Queensland, from 1885 to 1899. On returning to England in the latter year, having a sufficiency of means, he took up astronomy as a hobby and established a small observatory at Cobham, Surrey, where he occupied himself in the geometrical branch of the science, finding his longitude from occultations of stars by the Moon and making an ingenious determination of the variation of latitude during a short period by observation of star altitudes. Papers by him relating to the occultations of stars and apparent variation of the Moon's radius derived from them will be found in the *Journal of the British Astronomical Association* for 1905, in the *Astronomische Nachrichten*, No. 4206, and in the *M.N.* for 1908 June and 1911 May. In 1907 he published a pamphlet on occultation residuals in which he gave a table of values of the Moon's radius. Graphical methods for the conversion of co-ordinates was also a subject that had interest for him. He took much interest in the affairs of the British Astronomical Association and served as Secretary from 1916 to 1918. He was an active member of the Library Committee of our Society, making valuable suggestions and giving much time to this service at Burlington House. After the loss of his wife in 1926 he gave up his house at Cobham and led a rather nomadic life, but resolving to settle again he prepared to set up an observatory at a village near Hastings. Failing health, however, prevented this, and he died on 1932 May 6, less than a week before completing his seventy-seventh year, leaving no family.

He was elected a Fellow of the Society on 1901 January 11, and served on the Council from 1914 to 1917.

H. P. H.

FRANCISCA HERSCHEL was christened "Francisca" after Francis Baily. She was born at Collingwood, Hawkhurst, Kent, 1846 May 9, being the eighth daughter and eleventh child of Sir J. F. W. Herschel, Bart.

In face she bore a striking likeness to the picture in the National Portrait Gallery of her grandfather Sir W. Herschel as a young man, and again, in her old age, to his portrait which hangs in the Society's Council Room. From him she inherited a noticeable talent for music. She was a pupil

of Sir Charles Hallé and had a pleasant soprano voice, but her chief interest lay in conducting the Amateur Musical Societies in Hawkhurst and Slough.

She and others of the third Herschel generation returned to Slough in 1888, where her main occupation was the care of the Herschel papers and scientific instruments.

She was elected a Fellow of the Society in 1916, and on the centenary of Sir William Herschel's death she organized a meeting of scientists and astronomers to view the scientific relics connected with his work at Slough.

Francisca Herschel resembled her great-aunt Caroline in two respects, she was a little lady, hardly reaching five feet in height, and shared also the rare characteristic of subordinating her own aspirations to her enthusiasm for another's cause. For many years her life was spent in providing happiness for her mother or her invalid brothers till they severally passed away, and then, till her own death, she faithfully continued the collecting and sorting of materials for a life of her father, which she had hoped to have seen published.

She died at Slough on 1932 September 25, beloved and respected by those who appreciated the unobtrusive goodness of her character.

M. F. H.

RHISHARD LLEWELLYN JONES was born at Pempompren, Uchaf-Talybont, Cardiganshire, on 1865 June 12. He was educated at the British School, Talybont, and subsequently at Ardwyn House School, Aberystwyth. From the latter school he gained a scholarship to Corpus Christi College, Cambridge. After graduating as a wrangler he was appointed assistant master at Dulwich College. He held this post for about a year, at the end of which he was appointed Professor of Physics at the Presidency College, Madras. He was also Government Meteorologist and Deputy Director of the Kodaikanal and Madras Observatories. He retired in 1920, and died on 1932 March 3.

He was elected a Fellow of the Society on 1895 December 13.

CYRUS AUGUSTUS MACFARLANE was born in the Clarence River district of New South Wales in 1865. He became a journalist by profession, and at the time of his death he was on the editorial staff of the *Brisbane Daily Mail*. He was a keen amateur astronomer.

He died on 1932 May 19.

He was elected a Fellow of the Society on 1931 January 9.

DONALD MACLEAN was a native of Ross-shire and as a young man came to Glasgow with the intention of studying medicine, but he became interested in astronomy, and accepted the position of assistant to the late Professor Grant at the Glasgow University Observatory, where he remained a number of years.

In 1883, when the Coats Observatory (the gift of the late Thomas Coats, Esq., of Ferguslie, to the Paisley Philosophical Institution) was nearing

completion, he was appointed Curator. It was only on 1931 April 30 that he retired after being nearly forty-eight years in charge of the Observatory.

Although the Observatory was originally only intended for astronomical work, the Meteorological Station, which had been carried on at Ferguslie House for fully a quarter of a century, was transferred after the death of Mr. Coats to the Observatory, where it was under Mr. Maclean's charge.

Mr. Maclean was a man of retiring disposition. He died on 1932 December 25 at Gallowlea, Meikleriggs, Paisley, in the eighty-first year of his age, having been predeceased by his wife by a few years.

He was elected a Fellow of the Society on 1912 December 13.

J. W.

NEAL McNEILL was born in Melbourne, Australia, on 1891 September 25. He became an engineer and surveyor by profession, and prior to the War he was engaged on survey work in Northern Australia and New Guinea. He served with the Australian Forces and, subsequent to his demobilisation in 1919, he was engaged on Government Survey work on the Gold Coast. In 1922 he was occupied on a survey on the Orinoco River and in Trinidad. His services were secured by the Earl of Plymouth as leader of the British Pacific Science Expedition, formed to explore and survey New Guinea, but owing to the sudden death of the Earl of Plymouth this expedition did not start. Mr. McNeill then went to Malaya with an engineering firm to build a big dam on the Perak River. In 1925 he was engaged on a Government Sanitation Scheme in British Guiana. He then returned to Malaya and was engaged on engineering work, but his active career was brought to a premature end by his death on 1932 March 30.

Mr. McNeill was one of the pioneers of civil aviation in Australia. He was married in Georgetown, British Guiana, in 1925, and is survived by his widow and one son.

He was elected a Fellow of the Society on 1923 January 12.

JOHN MASTIN was born at Marchamley, Salop, on 1865 October 15. He was educated firstly at Sheffield, and subsequently on the Continent. He was a man of great versatility. An artist of no mean repute, he gained in 1896 a gold medal of the first class in Paris, and he exhibited at the Royal Academy. He played the violin, composed music, and wrote many books, including metallurgical treatises and works of fiction.

At one time Dr. Mastin often came to the meetings of the Society, but for many years past he had been prevented, for reasons of health, from travelling to London from his home in North Wales. He died in 1932 July.

He was elected a Fellow of the Society on 1909 February 12.

FREDERICK WILLIAM NASH was born at Greenwich in 1849, and died on 1932 December 29. He was educated at Redhill in Surrey, and at Reigate Grammar School. A banker by profession, after a long and successful career with Lloyds Bank he ultimately became general manager of the Metropolitan Bank, which was merged in the Midland Bank in 1914. He

was elected a Fellow of the Society in 1889, and from an early age took an interest in astronomy and meteorology. He was one of those who encouraged the present writer in his early astronomical work, and was also one of the original members of the British Astronomical Association and a Fellow of the Royal Meteorological Society.

After his retirement he lived at Lapworth in Warwickshire, where he retained his interest in science until his death.

J. H. R.

SAMUEL OKELL was one of the oldest members of the Society. He was born at First Hill, Jamaica, on 1838 July 31. His father was a missionary in Jamaica under the London Missionary Society. Mr. Okell lived in England since 1841. He commenced his business career in 1852 as a junior with the firm of James Laing, Son & Co., Ltd., of Manchester and London, Drysalters, and gradually worked his way up until he became senior partner. He was actively associated with the firm for seventy-five years, only retiring in 1931. At different times he visited South America, South Africa and Jamaica, where he formed a lasting friendship with Professor William H. Pickering. His friends also included Richard A. Proctor, George Calver, A. A. Common, W. H. Maw and E. W. Maunder. On one occasion the last-named accused Okell of possessing the secret of everlasting life.

Mr. Okell, although a life-long student of the sky, and never lacking a telescope, was not a confirmed observer himself. At all events, he never had any specific programme of observational work to carry out. He used his telescopes for interesting and educating other people less fortunate than himself, and in his more active days there were hosts of visitors to his beautiful garden at Bowdon whenever anything of particular interest appeared in the sky. He was one of the founders of the Manchester Astronomical Society, of which he was vice-president at his death, and he attended its meetings regularly until he was nearly ninety-three years of age.

From R. A. Proctor Mr. Okell purchased an $8\frac{1}{2}$-inch Browning reflector. This instrument was followed by an $18\frac{1}{4}$-inch Calver reflector, purchased from Dr. Common. Later Calver built him a 20-inch reflector, but eventually this was exchanged with Samuel Chatwood, the safe maker, for an $8\frac{1}{2}$-inch Cooke refractor which he possessed at his death.

Mr. Okell was married twice, and had the distinction of celebrating two silver weddings. He is survived by his second wife and three sons.

Notwithstanding his great age Mr. Okell had to the last the complexion and mental vivacity of a young person. His life was one of great gentleness and wonderful good health. He died at his home at Bowdon, near Manchester, at the advanced age of ninety-four.

He was elected a Fellow of the Society on 1882 May 12.

W. P.

MONROE B. SNYDER was born on 1848 March 13. He graduated at the University of Michigan in 1872, and in the following year he was appointed instructor of astronomy at the Central High School, Philadelphia.

He eventually became head of the department of mathematics and astronomy and Director of the Observatory.

He was a man of general scientific interests. In 1884 he served as secretary to the United States Electrical Commission, which held an exhibition that year in Philadelphia. In the same year he suggested the establishment of a national bureau of physical standards, and sixteen years later he saw this idea materialise when the National Bureau of Standards was established.

He died on 1932 September 28.

He was elected a Fellow of the Society on 1901 November 8.

EDWARD WELDON, who for a large part of his life was the head of a firm engaged in the wholesale textile trade in London, was born in the neighbourhood of Greenwich 1860 March, the proximity to the Royal Observatory provoking an interest in astronomy in his early years that led him later to procure a 5-inch equatorially mounted telescope for inspecting the principal objects of the heavens. About the year 1900 he removed from Blackheath, taking his observatory with him, to Tunbridge Wells, where he interested himself in local public affairs, especially education and the conduct of the hospitals, retaining his connection with these when he settled in a small estate near Bexhill twenty years later. He was a cultured man of somewhat reserved disposition, with a taste for pictorial art that he was able to gratify. He died on 1932 February 6, leaving a son and two daughters, all of whom are married.

He was elected a Fellow of the Society on 1897 February 12.

H. P. H.

EDWARD TURNER WHITELOW died at his home at Birkdale, Southport, 1932 November 4, at the age of seventy-eight.

He was born at Elland, in Yorkshire, 1854 November 1. As a youth he was eminently studious, with strong leanings towards science and languages. Professionally he became a civil engineer, with headquarters at Manchester, trading in textile and other machinery, particularly with China and the Far East. His business activities also embraced the work of a patent agent. He was an excellent linguist.

Astronomically Mr. Whitelow was active to the last, although increasing physical weakness had prevented his using the telescope systematically for about a year. In his early days he possessed various instruments, but finally, on his retirement from business more than twenty years ago, he erected an observatory at Birkdale, in which he housed the $7\frac{1}{3}$-inch Alvan Clark equatorial refractor which originally belonged to the Rev. W. R. Dawes, but which afterwards passed into the hands of George Knott and Henry Pratt. Mr. Whitelow's work with this fine instrument consisted at first of double star observations, respecting which he maintained a connection with Burnham. In later years he devoted himself almost entirely to the photography of sunspots and small active areas on the solar surface. In this regard he derived much help and inspiration from Dr. Janssen at the Meudon Obser-

vatory, whom he had frequently visited. Some of the solar photographs Mr. Whitelow obtained are of remarkable clarity, but have only on one or two occasions been exhibited in public, principally at meetings of the Manchester Astronomical Society. Mr. Whitelow was continually engaged in perfecting his apparatus, as the Alvan Clark object-glass could not properly display its superlative excellence by way of photography in the absence of the finest possible accessory equipment. If he had lived longer he would have turned his attention seriously to small and selected regions of the Moon's surface. His first experiments in this direction turned out very successful, but he only allowed the results to be inspected by a few scientific friends. Realising that his end could not be long delayed, during the summer of 1932 Mr. Whitelow handed over his observatory and equipment to the Stonyhurst College Observatory.

In his later years Mr. Whitelow devoted much time to ordinary photography, becoming an acknowledged master of the bromoil and gum bichromate processes, including colour photography. He was also interested in microscopy.

Mr. Whitelow was elected a Fellow 1893 March 10. He was also a member of the British Astronomical Association, of the Manchester and Liverpool Astronomical Societies, and of many other organisations. For three years he served as President of the Manchester Astronomical Society. He possessed a natural charm of manner which endeared him to his friends.

Mr. Whitelow was married in 1879 to Miss Mary Rhodes, of Manchester, by whom he is survived.

W. P.

GUILLAUME BIGOURDAN.—We have lost in M. Bigourdan a veteran astronomer who for many years, at the Paris Observatory, worked with the utmost assiduity in the observations of the positions of nebulæ and clusters, and was later Director of the Bureau International de l'Heure from its commencement till 1928.

Born at Sistels (Tarn-et-Garonne) on 1851 April 6, he graduated at the École d'Astronomie in Paris, and in 1877 was appointed by Tisserand as an assistant in the Observatory of Toulouse. He was put in charge of the meridian instrument, but held this post for only a short time, as Tisserand was appointed Director of the Paris Observatory shortly afterwards, and brought Bigourdan to Paris in 1879, where he was given charge of the great equatorial. He at once commenced the great work of determining by visual observations the accurate positions of all the known nebulæ of the northern hemisphere. He never missed a fine night, and his observations are published in five volumes of the *Annales* of the Paris Observatory and occupy no less than three thousand pages. He gives a history of the discovery and previous observations of these nebulæ. The intention underlying these arduous observations was that the positions of these distant objects might be sufficiently well known for astronomers in the future to determine their motions. Incidentally he discovered many new nebulæ, and made measures of the positions of comets and of double stars.

In 1882 M. Bigourdan took part in the observations of the transit of Venus in Martinique. Profiting by his stay in the island, he made observations of the comet of that year for which he was awarded the Lalande Prize. In 1892 he went to Senegal to observe the total eclipse of the Sun, and on the same expedition made a determination of the value of gravity at Joal. In 1900 and 1905 he observed total eclipses of the Sun in Spain and Tunis.

Owing to discordances in the previous determinations of the longitude Paris-Greenwich, a redetermination was made in 1902. The French observers, M. Bigourdan and M. Lancelin, worked in parallel with the English observers, F. W. Dyson and H. P. Hollis. The previous discrepancy was cleared up and results obtained in satisfactory accordance, the concluded value differing only $0^{s}.01$ from the recent determinations, which had the advantage of a moving micrometer and wireless time-signals.

M. Bigourdan was interested in the transmission of time-signals by wireless, due so largely to the initiative of General Ferrié. On his suggestion the installation at Greenwich was erected in 1912, and the signals from the Eiffel Tower recorded daily. After the conferences at Paris in 1912 and 1913 the International Time Service was established, with a Bureau at Paris, of which M. Bigourdan was constituted Director. The War intervened, but after its conclusion M. Bigourdan remained Director in close touch with M. Baillaud and General Ferrié.

M. Bigourdan was made a member of the Bureau de Longitudes in 1903, and continually enriched the *Annuaire* with notices on interesting researches in current astronomy, such as determinations of parallax, classification of stellar spectra, variable stars. After his retirement from the Bureau de l'Heure in 1928, when he was seventy-seven years old, he gave in the *Annuaire* a history of the Bureau de Longitudes. The fourth part of this history was published in 1932, only a short time before his death. His most important historical work, *Annales célestes du dix-septiéme siècle*, by A. G. Pingré, has a curious history. The manuscript was completed in 1791, and a beginning made of its publication. This went on very slowly till the death of Pingré and then ceased. The manuscript was lost, and found by M. Bigourdan at the Paris Observatory under a wrong designation. It was printed in 1901 under the auspices of the French Academy.

M. Bigourdan was elected a member of the Académie des Sciences in 1904, and became Vice-President in 1923. He attended many astronomical conferences, both in Paris and other cities, where he put forward his views with vigour and courtesy.

He married a daughter of Admiral Mouchez, the Director of the Paris Observatory, who inaugurated the Carte du Ciel.

M. Bigourdan was elected an Associate of the Royal Astronomical Society on 1903 November 13, and was awarded the Gold Medal in 1919.

F. W. D.

GUSTAVE FERRIÉ was born in 1868. He was a student at the École Polytechnique, and became Sub-lieutenant of Engineers in 1889. He remained throughout his life a man devoted to the Army, and passed

through its various grades in due course, until as General, and possessing many distinctions and honours, with the whole organisation of army communications under his control, as a culminating honour he was retained for service by a special law, setting aside in his case the fixed age for retirement. In all his career he showed an admirable energy, which he never spared, with a capacity for organisation and a clearness and economy of statement that were a sheer pleasure to witness. He had a strong constitution, from which in the end he asked too much, for he died at the age of sixty-four. It would be impossible to exaggerate the feeling of devotion he aroused, as one who never spared himself, especially when there was hard or dangerous work to be done. His modesty was inherent in his nature. He cultivated his subject of communications, not only because it formed the nervous system of the army, but with an unflagging enthusiasm in which the settled will of the man enshrined all that was permanent and best in the outlook he had brought to it as a youth. This side of Ferrié's life is fully detailed by his friend and colleague, Col. Brenot, to whose Memoir those interested may be referred; several of the facts of this notice are drawn from his account. Changing the unique features, possibly nearly the same might be said of many officers. They are well worth knowing; but as scientific men we may pass them aside, and we shall confine what follows to his scientific influence, remembering only that, however important, it was a mere parergon.

It was not Ferrié's habit ever to put together any claim or case for himself, and this makes it barely possible, nor should one try, to separate the contributions of individuals to a subject like radiotelegraphy, which began within the lifetime of many of us, in obscurity, as an unformed, inchoate infant. A great many people were working at it. Across the page of its history comes the War, when ideas and methods were borrowed, taken, given, with no acknowledgment possible. Suffice it to say that Ferrié began in 1898, with a certain authority indeed, but provided with resources almost ludicrously inadequate, such as seemed to express all that was worst of official distrust and appeared to be directed to produce a failure instead of a success. Eleven years this kind of thing lasted, and would have stifled development under hands less indomitable and enthusiastic than Ferrié's. With him it only perfected his readiness to accommodate every point of view that did not clash with his main object. Compared with these almost recent days, the present position, when we cannot think radiotelegraphy away, forms a complete contrast. It is not implied that all the incidents of advance are due to Ferrié alone, nor would he wish that that should be said; he was always a good friend, and knew and valued many men; nor had he any narrow national ambitions. But we may safely say that what he did not do himself he encouraged and made possible for others by his heartening support.

A characteristic feature of Ferrié's scientific view, and one which he was very well placed to effect, was international organisation, in which astronomers have long led the way. One of the earliest of these was the International Conference on Time, summoned at the invitation of the

French Government in 1913. Ferrié took a prominent part in this, both as an organiser and as one of the secretaries. The time-signals then issued from the Eiffel Tower, as well as those originating in the United States, marked a course that required regulating. A convention was reached, not without difficulty, which was more or less of a diplomatic character. In the end, the War intervened and no country ratified it. But its terms served as a model for much of the first statutes of the I.A.U., drawn up at Brussels in 1919, in which it was partly incorporated. In post-war days the position, needless to say, was much altered, and from this time dates the wider knowledge of Ferrié among astronomers. He was first President of the Commission No. 18—On Longitude by Wireless Time-Signals—a commission shared between the I.A.U. and the I.G.G.U.—and he was Vice-President of Commission No. 31—On Time. The organisation of time reception was centred at the Observatory of Paris, as well as certain duties of emission of time-signals also. It is fair to say that neither of these would have been practicable without the resources that Ferrié could then command and was willing to use. Further, he was an intimate friend of M. B. Baillaud, then Director of the Observatory, and the Observatory owes much to his advice, assistance, and indeed to his inventions. Among the last is a clock, dependent for maintenance upon a photo-electric cell, so that the pendulum is kept in oscillation, and its oscillations counted, without any mechanical contacts whatever. This piece is still in use.

He was also the originator and first president of the International Union of Scientific Radiotelegraphy.

But what most astronomers and geodesists will recall is his work in connection with Commission No. 18 of the I.A U. in organising a revision of World Longitudes by Wireless Time-Signals. He saw clearly that long-distance wireless reception offered a unique opportunity for binding into one the longitudes of the whole world in a way that had never been possible before. To work out a plan, and to obtain the consent and co-operation of the very numerous countries and individual astronomers concerned, was a different matter. It may safely be said that it would not have been possible, or at least it would have been seriously protracted, without Ferrié's drive and capacity. Nor, we may notice, would it have been possible, without the existence of the international unions concerned ; and if it stood alone it would of itself justify their utility. As it was, he only saw completed a preliminary essay made in 1926 ; but that was on so large a scale, and yielded so many valuable results, as to leave no doubt that it ought to be repeated in a definitive manner, which it is hoped to do in the present year.

Ferrié was married to a devoted wife, who survives him. They leave no children. He was elected Associate on 1928 June 8. He died on 1932 February 16.

R. A. S.

MAX WOLF was born at Heidelberg on 1863 June 21. The son of Dr. Franz Wolf, a well-known medical man in the town, he was educated at Heidelberg University, where at the age of twenty-five he took the degree of

Ph.D., after having achieved distinction as a mathematician. He began his astronomical career at the age of sixteen, with a small observatory erected for him by his father, and in 1884 he discovered his first comet, which had a period of about six years. After spending a year in Stockholm he returned to his own university in 1890, with the position of "privat-docent" in astronomy. From this time onwards he rapidly made his way. In 1893 he was appointed to a special Professorship in Astrophysics and Director of the new observatory at Königstuhl, near Heidelberg. In 1900 he was invited to become Professor of Astronomy at Göttingen, but declined the invitation. Two years later he was appointed to the Chair of Astronomy in Heidelberg University, a position, together with the directorship of the observatory, which he retained until his death on 1932 October 3.

Max Wolf recognised the importance of photography as applied to astronomy at the outset of his career as a professional astronomer. He applied it first of all to the Galaxy with a short focus lens, and obtained results which attracted much attention owing to the new light they shed on the stellar and nebulous structure of the galactic system. It was, however, by the first discovery of asteroids by photography that Max Wolf made his mark. The first of these bodies to be discovered in this way was photographed with a 6-inch Winnecke triplet on 1898 September 11. By the end of the year nine others had been found, and since that time every year has yielded a rich harvest of new asteroids, so that by 1929 a total of 1300 had been reached. Some of these were rediscoveries of asteroids for which only rough ephemerides had been worked out, but most of them were new. The ever-growing numbers of these faint minute bodies at last dismayed Wolf by the apparent impossibility of reaching finality.

Of greater importance and interest was his work in the photography of nebulæ, both galactic and extragalactic. He issued sixteen "Lists of Nebulæ" containing about 6000 objects in selected regions, the great majority of which did not appear in the N.G.C. Amongst his discoveries in this direction, the groups of small elliptical nebulæ in Coma and Perseus may specially be mentioned, as the luminosities and radial velocities of members of these groups have been of great importance in recent years. In his studies of the diffuse nebulæ in the Galaxy he laid special stress on the abnormally small number of faint stars in their proximity, a feature we now connect with the clouds of dark matter blotting out the stellar regions beyond, but illuminated by bright stars so as to appear as diffuse nebulosity.

In 1908 Wolf began his spectrographic work on nebulæ. Spectra of twenty-six diffuse and planetary nebulæ, with sixteen of other types, confirmed and greatly extended the pioneer work which had been done by Huggins in England, at the Lick Observatory, and by Slipher in America. He was the first to use a slitless spectrograph for this work, and discovered the different distribution of shells of various radiations in the planetaries. The obvious relationship of the spectra of planetaries to novæ and Wolf-Rayet stars soon induced Max Wolf to interest himself in both these classes of stars. Although his spectrographic dispersion would now be considered

too small to deal adequately with the less conspicuous features of the spectra, in 1915 he published curves showing the distribution of radiation in sixteen Wolf-Rayet stars. These he divided into two groups, which correspond to Oa and Ob of the Harvard classification.

His work on the extragalactic nebulæ was of outstanding importance. Notwithstanding the difficulty of getting a satisfactory density in the photographic spectra of these systems even in the nuclear regions, he was able to record photographically the solar type of spectrum already suspected, and to confirm Slipher's large negative radial velocity of M31. He also discovered rotation in M81, where the Doppler shift of a point near the nucleus was found to correspond to 100 km./sec.

Of his work with the stereocomparator, and of the application of the instrument to stars having large proper motions, and of his linking up photography with photometry it is impossible to speak adequately here in detail, but these are only two of many optical methods which interested him.

Besides being an Associate of the Society, he was our Gold Medallist in 1914, an honorary member of the American Astronomical Society and a foreign Associate of the National Academy of Sciences. He received also the Bruce Medal of the Astronomical Society of the Pacific in 1930. He was essentially an observational astronomer of the first rank, and in the course of a busy life he made many friends on both sides of the Atlantic. He will always be remembered as one of the pioneers in the application of photography to astronomy.

He was elected an Associate of the Society on 1903 November 13.

J. H. R.

PROCEEDINGS OF OBSERVATORIES

The following reports of the proceedings of observatories during 1932 have been received from the respective Directors, who are alone responsible for them.

Royal Observatory, Greenwich
(*Director, Sir Frank Dyson, K.B.E., Astronomer Royal*)

Transit Circle.—The number of transits observed was 10,542, including 123 of the Sun and 79 of the Moon.

A catalogue of stars for 1925 is nearly completed from the observations 1922 January to 1930 December 31. This will contain revised proper motions for 1950 stars in Boss's Catalogue and for all the stars brighter than $8^{m}.0$ between the limits of declination $+32°$ to $+64°$.

Cookson Floating Zenith Telescope.—The numbers of plates taken for the determination of variation of latitude were :

January—23	May—20	September—21
February—13	June—21	October—22
March—31	July—15	November—15
April—22	August—33	December—26

Seven additional plates were taken for determination of scale.

28-*inch Refractor.*—435 measures of 282 double stars were secured. Arranged according to separation they are :

$<0''.5$	62	observations
$0''.5 - 1''.0$	134	,,
$1''.0 - 2''.0$	120	,,
$>2''.0$	119	,,

26-*inch Refractor.*—The number of plates obtained suitable for the determination of stellar parallax was 1097, and 1163 plates were measured. The parallaxes of 45 stars have been published in the November number of the *Monthly Notices.*

The copy for press of *Observations of Stellar Parallax*, vol. ii, containing the parallaxes of 251 stars, has been sent to the printers.

30-*inch Reflector.*—The work on colour temperatures has been continued. 30 comparisons of standard stars were secured, these completing the intercomparison of the standard stars.

A volume containing the Absolute Colour Temperatures for the 25 standards and 38 other stars has been published. Subsequent to its preparation the work has been resumed, and 69 comparisons of 29 stars with the standards have been secured. These include 12 comparisons of δ Cephei, made at various phases.

Astrographic Equatorial.—The only observing with this instrument consisted of 5 supplementary plates for proper motion, and a series of photographs of the eclipsed Moon on September 14.

Copy for press for vol. vi of the *Astrographic Catalogue*, containing the determinations of proper motion of stars between Dec. $+72^{\circ}$ and the N. Pole, has been prepared and the volume printed.

The measurement of the comparison stars to be used in the reduction of the Eros photographs is in progress. The rectangular co-ordinates of 1970 stars have been measured, most stars having been photographed on two plates with two exposures on each plate.

Photoheliograph.—The Sun was photographed on 271 days at Greenwich and on 336 days at the Cape. There are 4 days not covered by either series, but plates for these dates are available from Kodaikanal.

The mean daily spotted area, corrected for foreshortening, for 1932 was approximately 165 millionths of the Sun's hemisphere. The published values for 1924–31 are 276, 830, 1262, 1058, 1390, 1242, 516 and 275.

Sunspot numbers have been supplied quarterly to Zurich.

Spectrohelioscope.—Observations were made on 171 days. They include measures of radial velocity of 166 dark flocculi associated with sunspots. A summary of the observations made during 1931 was published in the *Monthly Notices* for 1932 March, and one for 1932 has been communicated to the Society.

Clocks and Time-Service.—Observations for clock correction were made on 72 nights with the small reversible transit " B."

The free-pendulum clocks, Shortt Nos. 3 and 11, have been in use as sidereal standards. In February a pendulum with invar rod and 14-lb. bob, with a steel suspension spring, was fitted to Shortt No. 3.

The mean time free-pendulum clock, Shortt No. 16, has controlled all mean time signal distribution. Wireless time-signals have been transmitted daily to Rugby and the B.B.C. stations, and hourly time-signals to the General Post Office. A daily registration has been made of the signals received from Rugby, Nauen, Annapolis and Bordeaux.

Eclipse of 1932 *August* 31.—The observations secured at Parent, Quebec, have been published in the *Monthly Notices* for November. An excellent flash spectrum was obtained.

Printing.—The volume, and separate parts, of *Greenwich Observations* for 1930, and also a volume entitled *Observations of Colour Temperatures of Stars*, have been distributed. The final proofs of *Greenwich Observations* for 1931 and of *Astrographic Catalogue*, vol. vi, have been passed. The MS. of *Observations of Stellar Parallax*, vol. ii, has been dispatched to the printer.

New Instruments and Buildings.—Satisfactory progress has been made with the construction of the new transit circle by Messrs. Cooke, Troughton & Simms, and of the new 36-inch reflecting telescope by Messrs. Grubb, Parsons & Co. The building for the reflector has been completed by the Civil Engineer's Department of the Admiralty, who have also completed the collimator houses and the foundations for the new Transit House. A

copper-covered dome for the reflector has been erected by Messrs. Grubb, Parsons & Co., and moves with the greatest ease.

The 36-inch reflector, with building and dome, are the gift of Mr. William Johnston Yapp.

Miscellaneous.—Senhor J. A. Madeira of the Observatory of Coimbra, and Mr. S. Kawasaki of the International Latitude Observatory, Mizusawa, Japan, have both worked at the observatory during the year.

Royal Observatory, Edinburgh

(*Director, Professor R. A. Sampson, F.R.S., Astronomer Royal for Scotland*)

The time-keeping of three fundamental clocks, Riefler No. 258, Leroy No. 1230 and Shortt No. 0 has been very good, especially the Leroy clock, though this has a needlessly great temperature coefficient. It was found impossible to cure a slight leak in the case of the other clock, Shortt No. 4, and finally a new pattern case was obtained. The fittings necessary for the transfer were made and it is now in use. A prolonged test has not so far been possible, but the change appears to have cured the leak.

The Great Reflector in the East Dome was exposed to a series of Hartmann tests in which both mirrors were used *in situ*; several attempts were made to produce perfected results by retouching the smaller mirror by the makers, but without success. In the end the small mirror was treated independently and the pair put under test together. They are now passed as practically correct, *i.e.* for the combined instrument, $T = 0{\cdot}2$, corresponding to a diameter of stellar image $0''{\cdot}4$, which is smaller than atmospheric conditions allow to be realized.

The Hartmann tests *in situ* proved to be easily practicable and very reliable.

The Great Mirror was afterwards dismounted, resilvered and replaced, successfully, without incident.

The spectrograph, now under temperature control, was attached, and a series of tests made, which are still in progress, on the capabilities of the different 1, 2, 3 prism systems, in conjunction with the three cameras. A change has been made, in the use of films instead of plates, bending these upon suitable formers so that the whole spectrum is in sharp focus together.

The equipment of the West Dome was installed in the summer. It consists of the old 15-inch refractor, rebuilt and modernized, together with a 10-inch Dennis Taylor photographic triplet, of 60 inches focal length, which will take either a 12×10-inch plate, or a 16×16-cm. plate, as desired, together with provision for attachment of any other small instruments that may be required. The mounting and drive is generally similar to that of the Great Reflector. Tests were made of the triplet before erection. These are now being continued. The instrument promises well.

The normal services in meteorology and seismology have been continued as heretofore.

The established staff remains unchanged.

Royal Observatory, Cape of Good Hope
(Director, Dr. H. Spencer Jones, F.R.S., H.M. Astronomer)

Reversible Transit-Circle.—The number of transits observed during the year was 8887, including 208 of the Sun, 80 of Mercury, 135 of Venus and 13 of Vesta. The programme of observation, commenced in 1925, comprising stars brighter than $7^m{\cdot}5$ south of decl. $-30°$ and zodiacal stars, has been completed; the working list comprised about 11,500 stars, each zodiacal star being observed, in general, three times in each of the two positions of the instrument and the other stars twice in each of the two positions; about 72,000 observations were obtained for this programme. The positions of the zodiacal stars, as soon as available, will be communicated to the Naval Observatory, Washington, for incorporation in the new Zodiacal Catalogue under preparation there.

The new programme of observation comprises stars down to magnitude $7^m{\cdot}5$ between the equator and decl. $-30°$, supplemented by fainter stars where necessary to give an approximately uniform distribution in right ascension. The working list contains 7400 stars.

Current reductions are well advanced and ledgering is in progress. The computation of the tabular places of the Sun, Mercury and Venus for the discussion of the day observations for the period 1925–1932 is in hand.

8-inch Transit-Circle.—Observations of 2143 transits have been obtained for the determination of the positions of reference stars required for the reduction of plates in the zone $-30°$ to $-35°$ decl. taken with the wide-angle lens. This programme of observation is nearing completion, and the instrument is only used intermittently in the portions of the catalogue where observations are still required.

Zone Observations.—The wide-angle lens camera was in use on 52 nights, 68 plates in the zone $-30°$ to $-35°$ decl. being obtained and 2 plates of the south polar area. Three exposures, each of 20 minutes, are being secured on each plate, and the plates overlap in right ascension so that each star appears on at least two plates. The photography of this zone is nearly completed. The measurement of the plates cannot yet be commenced, as the long-screw measuring machine is fully occupied with the measurement of Eros plates.

Victoria Telescope.—The instrument was in use on 252 nights during the year. 2042 plates for stellar parallax and 81 plates for proper motion in declination of parallax stars were obtained. 1505 parallax plates were measured during the year and the proper motions in declination of 10 stars were determined. A fourth list of parallaxes was published in the *Monthly Notices* during the year, bringing the total number of parallaxes published to 416. 31 additional parallaxes have been determined but have not yet been published.

A copy for press, to form a part of the *Cape Annals*, has been prepared giving details of the measures of the parallax stars published in the first

two Cape lists (216 stars). The printing of this copy is held in abeyance, pending the completion of the measures of the proper motions in declination of the stars.

Astrographic Telescope.—This instrument was in use on 15 nights for miscellaneous purposes as follows: Grating areas along path of Eros, 2 plates; for calibration of grating plates, 10 plates; Comet Houghton, 9 plates; Comet Forbes-Dodwell, 3 plates.

Proper Motions of Stars in C.A. Zones.—The determination of the proper motions of stars in the C.A. Zones, from direct comparison of the original and recent plates, is nearing completion. The checking of the reductions and the formation of the proper motions has been completed. The measures of the proper motions of the same star from different plates in the same or adjacent zones have been collected, and weighted means are being derived. The weighted means for zones $-41°$, $-42°$, $-43°$ and $-47°$ have been computed. The measures of images more than one degree from the plate centre are being excluded in the formation of the means.

The final result will be a catalogue giving the proper motions of about 40,000 stars, viz. the stars in the *Cape Zone Catalogue of* 20,843 *Stars* (1923), together with about 20,000 fainter stars which have been found to have sensible proper motions. For the fainter stars, the right ascensions and declinations have been computed from the rectangular co-ordinates and will be published, along with precessions and secular variations. For this purpose the conversion of 40,925 rectangular co-ordinates into right ascension and declination was necessary. The checking of α and δ from measures in adjacent zones has been completed and all the positions have been ledgered. The computations of precessions and secular variations are well advanced.

The catalogue will give also photographic magnitudes based upon the measures of diameters on the C.A.Z. plates and upon the C.P.D. magnitudes. These are being reduced to as homogeneous a system as is possible, by means of the corrections given on pp. lxxiv–lxxxiii of *Magnitudes of Stars contained in the Cape Zone Catalogue of* 20,843 *Stars* (1927). The ledgering of the magnitudes for the zones $-40°$ to $-43°$ and $-45°$ to $-47°$ has been completed.

Opposition of Eros.—The measurement of the series of plates obtained with the astrographic telescope was commenced about the end of July, after the publication by Professor Kopff of the final portion of the catalogue of primary reference stars. Up to the end of the year the measurement of 175 plates obtained on the 22 nights from 1931 March 10 to April 1 has been completed. Each plate is being measured direct and reversed in both right ascension and declination. There are normally 6 exposures per plate, though on some plates there are 4, 5, 7 or 8, and on the average 10 comparison stars per plate have been measured. The weights of some of the primary star places being rather low, more comparison stars have been measured than would otherwise have been necessary. Where selection is possible, stars of extreme colour have been excluded, and an attempt is made to keep the mean colour index of the stars approximately equal to that of Eros. The computation of the standard co-ordinates of the

comparison stars and the reductions of the measures are proceeding *pari passu* with the measuring.

More than 1200 photographs of Eros were obtained with the astrographic and Victoria telescopes at the opposition of 1931. Only one long-screw measuring machine is available for the measurement of the plates. It is anticipated that the measurement of the complete series will take about three years. The measurement of the wide-angle lens plates must necessarily be deferred until the measurement of the Eros plates is completed.

The measurement of the series of path plates, for the determination of the positions of secondary comparison stars, has not yet been commenced, but it is hoped that it will be possible shortly to start this measurement.

The series of plates taken with a coarse wire objective grating has been measured and discussed. The measures have been reduced to a homogeneous system by the application of corrections to reduce to the centre of the plate and to the zenith. Correlations of Δ, the distance between the first diffracted images, with spectral type and with magnitude, have been derived. Δ is smaller for blue stars than for red, and is smaller for faint stars than for bright. The primary comparison stars were selected for visual observation, and the blue stars tend to be photographically bright and the red stars photographically faint; the method of selection of the stars thus tends automatically to reduce, in the mean, the effects due to difference of colour between red and blue stars. The variation of Δ with colour is found to be smaller than in the case of plates taken with a reflector. Observations with a refractor are thus favourable to a determination of the solar parallax in which systematic errors due to colour remain small.

The general conclusion of the investigation is that the effects of differential atmospheric dispersion are complex in nature and may introduce errors into the solar parallax in three ways: (*a*) through difference of colour between Eros and the reference stars; (*b*) through difference of magnitude between Eros and the reference stars; (*c*) through the positions of the reference stars on the plate.

The individual determinations of the colour of Eros show a rather wide scatter. The determinations are very sensitive to temperature effects and slight changes in focus. Departure from planeness of the plates will also introduce variations. The mean of the most reliable determinations corresponds to a colour for Eros corresponding to that of a star of type G8, in close agreement with the result obtained at Brussels by MM. Delporte and Bourgeois.

Heliometer.—The following observations of major planets near opposition were obtained :—

Opposition of Jupiter	...	48	obs.	in	distance	on 7	nights.
,, ,, ,,	...	48	,,	,,	position angle	,, 7	,,
,, ,, Neptune	...	54	,,	,,	distance	,, 8	,,
,, ,, ,,	...	44	,,	,,	position angle	,, 7	,,
,, ,, Saturn	...	72	,,	,,	distance	,, 6	,,
,, ,, Uranus	...	84	,,	,,	,,	,, 6	,,

The reductions of the observations to the end of 1931 have been completed. Copy for press of the observations for 1922 to 1931 inclusive has been made and sent for printing as a part of *Cape Annals*, vol. xiii. Heliometer observations of the major planets have been regularly made at the Cape since 1897. It is proposed to make a definitive reduction of these observations when the new Zodiacal Catalogue becomes available; in the meantime the observations will be continued as hitherto.

Occultations.—16 observations were made of disappearance at the dark limb, 3 of reappearance at the dark limb and 1 of reappearance at the bright limb.

The observations for the years 1923 to 1931 inclusive have been reduced and equations of condition formed. The results have been published in the *Monthly Notices.*

Photoheliograph.—699 photographs of the Sun, including 28 for zero, have been obtained on 336 days, to supplement the Greenwich series. In addition, visual observations for zero have been made weekly. Original negatives to 1932 November 15 and duplicate negatives to 1932 October 6 have been sent to Greenwich.

Time-Service and Wireless Signals.—The sidereal free-pendulum clock, Shortt No. 10, was opened on 1932 November 16 in order to alter the rate. The clock had not previously been opened since 1930 September 9. The secular change of daily rate amounts at present to $+0^{s}\cdot12$ per year. The mean time free-pendulum clock, Shortt No. 27, controls the emission of time-signals from the Slangkop wireless station and from the studio of the South African Broadcasting Association. The short-wave emissions from Slangkop of the Onogo signals at 9 a.m. and 9 p.m. S.A.S.T. were discontinued by the Union Government from 1932 January 24.

Observations of the Rugby 10^{h} G.M.T. signal were made on 257 days, and of the Bordeaux 8^{h} G.M.T. signal on 258 days.

Night Sky Observations.—Observations to determine the brightness of the night sky, with the instrument supplied by Lord Rayleigh, were obtained on 144 nights between March and December.

Seismograph.—Observations with the Milne-Shaw seismograph were discontinued at the end of 1931, and the seismograph has been set up in the Department of Applied Mathematics of the University of Cape Town. The results obtained from the daily records of 1931 have been forwarded to the University Observatory, Oxford, for incorporation in the International Seismological Summary.

Meteorological Observations.—During the second International Polar Year, commencing 1932 August 1, an extended series of meteorological observations are being taken at $8^{h}\ 30^{m}$, $12^{h}\ 46^{m}$, 15^{h} and 21^{h} (S.A.S.T.). Observations are also being taken at 3^{h} on Term Days of the first and second order. The results of the observations are telegraphed daily to the Meteorological Office, Pretoria.

Annals.—Vol. x, part 9 (completing vol. x), containing a discussion of the observations of the spectrum of Nova Pictoris, and vol. xiii, part 3, containing a rediscussion of the material contained in Newcomb's *Researches*

on the Motion of the Moon, part 2, have been published. Vol. xiii, part 4, containing the reductions of heliometer observations of the major planets, 1922 to 1931, has been sent to the printer.

It is with much regret that the death is recorded, on 1932 November 11, of Mr. R. W. Cheeseman. Mr. Cheeseman was the senior Assistant, and had for some years been in charge of the time service and of the meridian instruments.

Armagh Observatory
(*Director, Rev. W. F. A. Ellison*)

The transit instrument was only used occasionally, the clocks being checked by the wireless time-signal.

Observations of planets were obtained under improved conditions compared with 1931. Jupiter and Venus were well observed during the fine dry weather of the first half of the year. A dark transit of Jupiter III was well seen with the 18-inch reflector on the evening of February 18. Little of course was seen of Saturn, owing to unfavourable position. The 6-inch refractor was used for the Sun and Moon.

Several specula and object-glasses were made or corrected in the workshops for various people. One 4-inch objective had to have a new crown lens worked, and the result was most successful.

The Director went to Canada for the Solar Eclipse on August 31, and was absent from August 16 till September 17. Unfortunately, weather conditions were unfavourable at Magog.

Cambridge Observatory
(*Director, Sir A. S. Eddington, F.R.S.*)

Photo-electric work with the Sheepshanks telescope was begun six years ago, but until the current year it remained in an experimental stage. A new phase has now been reached, and since October the instrument has been used for regular observations ; the results attain high accuracy. The Moss potentiometer method, referred to in previous reports, is used. As the trial apparatus lent by the Cambridge Instrument Company had given rather promising results, an instrument of this pattern was ordered ; it immediately led to a great improvement. At present it is only possible to deal with bright stars, and the first undertaking has been an intensive study of the light-curve of Algol. Up to the end of the year observations had been secured on twelve nights by Dr. Smart and Mr. Green.

After the refiguring of the object-glass in 1931 it was necessary to test whether the definition or distortion had been altered in such a way as to affect the determination of proper motions from plates taken before and after. The test was carried out on the Pleiades, and it appeared that proper motion determinations can safely be made as before the refiguring. Measurement and reduction of proper motion plates has been continued ; 44 photographs for proper motion and double stars were taken during the year.

The Northumberland telescope has been provided with a new dome.

Mr. R. H. Stoy, B.A., has been working on problems connected with the physical condition of the planetary nebulæ, and Mr. J. E. Edgar, B.A., on the pulsation theory of Cepheids with special reference to the damping out of the higher harmonies, under the supervision of the Director.

Mr. M. H. H. Walters, B.A., has been working on the effect of stellar encounters on the orbits of binary stars, and Mr. C. G. Pendse, B.A., on dynamical astronomy, under the supervision of Dr. Smart.

Solar Physics Observatory, Cambridge University
(*Director, Professor F. J. M. Stratton*)

The Director returned from six months leave of absence in April. There are no changes of staff to report. Professor C. T. R. Wilson and Mr. P. I. Dee have continued their work on the mechanism of condensation and have used their cloud-track chamber in a study of the neutron. Mr. J. A. Ratcliffe and Mr. E. L. C. White have been studying variations in the ionosphere with the aid of a wireless transmitter installed in the new dome of the 20-inch Common reflector. Dr. R. v. d. R. Woolley, Isaac Newton Student, has been investigating the contours of lines in solar spectra. Mr. A. D. Thackeray, B.A., has been working with the Huggins refractor on stellar spectra in the green region.

Total Solar Eclipse of 1932 *August* 31.—For the first half of the year the whole time of the workshop and a large part of the time of members of the staff had to be devoted to preparations for the extensive programme of eclipse observations reported to the Society (*M.N.*, **93**, 9, 1932). The failure of the eclipse expedition owing to bad weather conditions was a great disappointment. The Director, Dr. Redman and Mr. Butler attended the meeting of the I.A.U. at Cambridge, Mass., immediately after the eclipse.

Solar Work.—During the autumn the installation of the spectrohelioscope has been completed, and regular observations, on a programme agreed with Professor Hale, have been commenced. The *Hα* side of the spectroheliograph has been overhauled, but further alterations have yet to be made to improve the performance of the instrument in the light of the *K* line. Solar activity continued to decrease, with a few unusually active revivals. Spectroheliograms have been received from the Director of the Kodaikanal Observatory, India, and photoheliograms from the Astronomer Royal, for record purposes and for character figures for inclusion in the Bulletin issued by the I.A.U.

Stellar Work.—In continuation of the study of line intensities in various stellar types, 99 spectrograms were secured with the Newall telescope and the 2-prism spectrograph. The 3-foot reflector, pending the completion of a spectrograph which is being constructed for it in the observatory workshop, is being used for a photographic study of the magnitudes of elliptical nebulæ. 113 photographs were obtained on 34 nights in the available clear moonless nights.

Meteorological Physics.—The installation of apparatus in the new hut has been completed and the instruments tested out. The usual observations

were made during a few thunderstorms, which occurred after the apparatus had been got into working order. The erection of the new building has removed many difficulties and effected a great increase in convenience of working.

Laboratory Work.—The work on the iron-arc spectrum has been continued, with special attention to the lines strengthened at the poles and to the relative strengths of lines in multiplets.

Dunsink Observatory
(*Acting Director, Mr. Charles Martin, M.A.*)

The time-service to Dublin has been continued as in previous years.

The observatory has been used mainly for teaching purposes, students being welcomed for instrumental instruction and observational work.

Durham University Observatory
(*Observer, Mr. Frank Sargent*)

The observation of the programme of variable stars has been continued, 598 measurements being made. The surface features of Jupiter have been under constant study. On 1931 February 18 and April 8 it was noticed that Satellite III appeared in a *dark* transit. A few observations of Venus have also been made.

Daily meteorological observations have been recorded.

The seismograms taken with the Milne-Shaw seismograph from 1931 January 1 to 1931 June 30 have been analysed and reported to the International Bureau at Oxford for publication.

A special study of microseisms has been initiated with the assistance of a research student.

It is proposed to erect instruments to take continuous observations of the atmospheric potential gradient and of the earth-air current. Details are being worked out.

With the voluntary assistance of Dr. W. Hall and Mr. H. W. Davis the Observatory Library has been completely catalogued. It is proposed to attach the Library to the Regional Library Scheme, so that astronomers in the district may have access to the accumulated scientific literature.

Liverpool Observatory and Tidal Institute
(*Director, Professor J. Proudman; Associate Director, Dr. A. T. Doodson*)

Tidal predictions of high and low water have been made for 69 places; of hourly heights of water for 2 places; and of times of slack water for 3 places. Five years' records of tidal observations from 5 places have been analysed. Fruitful research has been carried out on the meteorological perturbations of British tides and on the dynamical theory of tides. In

the latter work Messrs. Street and Grace, of the University of Liverpool, have co-operated.

The regular meteorological and seismological services of observation and transmission of information, and the firing of the time-gun, have been continued unbroken.

In April the Director attended at Monaco the Third International Hydrographic Conference as a representative of the International Association of Physical Oceanography.

University of London Observatory, Mill Hill, and University College Observatory

(*Director, Professor L. N. G. Filon, C.B.E., F.R.S.; C. C. L. Gregory, Wilson Observer*)

Wilson Reflector.—This was used on 29 nights. 26 plates were taken, mostly on Wilson regions. Herbert's standard photometer was used on 4 nights. From the beginning of May, the telescope was fitted with an extension to prevent direct sky light falling on the plates during photography at the Newtonian focus. Two portrait lens cameras, one with a 4-inch, the other with an 8-inch lens, were made in the observatory, and successively mounted on this instrument. The plate holder of the smaller instrument was kindly presented to the observatory by Mr. Walter Goodacre. A number of plates were taken, mostly for test purposes.

Rowland Grating Spectrograph and 8-inch Cœlostat Telescope.—A number of plates were taken with the grating spectrograph for members of the second positive group of nitrogen bands. These were required to complete some earlier measurements of these bands. The cœlostat was fitted with the larger mirror mentioned in last year's report. A number of plates were taken with the Littrow spectrograph, and measurements were also made with Herbert's bridge amplifier.

Fry 8-inch Refractor.—This instrument was used on 103 nights. 27 plates were obtained of double stars, using a yellow filter. 70 observations of sunspots and a few measures were made with the double-slit interferometer.

Measurement of Plates.—Miss White continued this work until the summer vacation. The results of the measurements were published by her in *M.N.*, **92**, 519, 1932, and *M.N.*, **93**, 105, 1932.

Occultations.—A list of occultations was published in *M.N.*, **93**, 111, 1932.

Visitors.—There were 243 visitors during the year.

University College Observatory.—The work, which is mainly instructional, has been carried on as in previous years. The weight-driven clocks, which had been giving a certain amount of trouble, were replaced by a Synchronome master clock in the transit circle observatory, and dials in the Brocklebank and Chadwick observatories. The seconds and half-minute impulses of the master clock were relayed to the Grubb chronograph. These clocks now work in a very satisfactory manner.

Radcliffe Observatory, Oxford
(*Director, Dr. H. Knox-Shaw, Radcliffe Observer*)

At the beginning of the year there were still 29 plates required to complete the observational part of the programme on proper motions in the Selected Areas. At the end of the year this number had been reduced to 9, 20 plates having been passed for measurement out of the total of 37 taken during the year. But unless more favourable weather is experienced in the first two months of 1933 than in the last three of 1932, when only two satisfactory plates were obtained, it will not be possible to finish off the programme until next winter. Measurement and reduction are well advanced, 106 out of the total of 115 areas in the "systematic plan" being completed. Press copy is being prepared, and the printing of the catalogue has actually started.

The volume containing the results of the reduction of Hornsby's observations was published in June.

The application of the Radcliffe Trustees for permission to transfer the Observatory to Pretoria is now before the Court of Chancery, and it is hoped that a decision will not be long delayed.

University Observatory, Oxford
(*Director, Professor H. H. Plaskett*)

Astrophysics.—With the aid of a special grant of £400 from the University for the study of solar radiation, apparatus which includes a Hilger All-Metal Medium Glass Spectrograph has been purchased and mounted in a small shelter on the roof of the observatory. As a result of numerous experiments and trial exposures during the summer, an arrangement of apparatus has been found which gives promise of making possible an accurate determination of the absolute energy distribution in the pure continuous spectrum originating in the centre of the solar disc. It is hoped that the observational part of the programme will be completed during the coming spring and summer.

Spectra of solar granulation, obtained by the Director at Victoria in the summer of 1931, are being measured on a registering microphotometer. This instrument, which was very kindly loaned to the observatory until February by the Astronomer Royal, has been fitted with a thermo-couple, galvanometer and apochromatic objectives ; after a number of preliminary trials it is now giving very satisfactory results.

Astrographic Catalogue.—The observatory has definitely undertaken to observe afresh zones $+32°$ and $+33°$ of the Potsdam section of the Astrographic Catalogue. Up to the present some 79 satisfactory plates have been secured, and 57 of these have been measured and completely reduced. The work will proceed slowly.

Seismology.—The Observatory and British seismology in general has

suffered an irreparable loss through the death of Dr. J. E. Crombie. The preparation of the International Seismological Summary, initiated by Professor Turner, has gone on as usual. The last two quarters for the earthquakes of 1928 have been prepared, printed and distributed, and the first quarter for 1929 is now in press. The two Milne-Shaw seismographs have been in almost continuous operation throughout the year, and have recorded over 130 earthquakes.

Norman Lockyer Observatory, Salcombe Hill, Sidmouth
(Director, William J. S. Lockyer, M.A., Ph.D., Major (late R.A.F.))

The Kensington 9-inch prismatic camera has been in regular use for photographing the spectra of some selected bright Be-type stars, and 149 spectra have been secured. The McClean 12-inch prismatic camera has been in occasional use, chiefly for securing the spectra of the fainter B-type stars, and 57 spectra have been obtained. The Mond photographic equatorial has been used on moonless nights for photographing, with long exposures, the Orion nebula, the Pleiades, and the America nebula. A special photograph was secured of the "Polar Sequence stars" with an exposure of one hour. Seven photographs in all have been taken.

There were only 106 fine nights during the year, which is considerably below the average of the past twelve years, namely, 128, and is 24 less than last year. Successful observations were made on 93 of these nights.

Work has been confined to studying the bright hydrogen line Be-type stars, and to the classification and determination of parallaxes of B-type stars in general. A paper has been published describing some peculiarities in the spectra of these stars (*M.N.*, **92**, 389), and another on the bright meteor photographed on two plates with the Mond photographic equatorial on January 11 (*M.N.*, **92**, 449).

On May 28 the new Mond dome was officially inaugurated by the Astronomer Royal in the presence of Sir Robert Mond (the donor), Sir Richard Gregory, Dr. R. G. Aitken, members of the Corporation, and a large number of guests.

The Director was attached as an unofficial member of the Cambridge Solar Physics Observatory expedition to Magog, Canada, to observe the total solar eclipse of August 31. A 4-inch Zeiss coronagraph was used, but an overcast sky spoilt all observation. He also attended the International Astronomical Union meeting held at Cambridge, Mass., from September 2 to 9.

The observatory is open to the public on Wednesday afternoons, and in addition was visited by larger parties by special arrangement, including students from the University College of the South-West (Exeter) and the visitors mentioned above in connection with the opening of the Mond dome. The total number of visitors who attended during the year was 463.

The sixteenth annual general meeting of the Norman Lockyer Observatory Corporation was held in London on June 14.

Stonyhurst College Observatory
(Director, Rev. J. P. Rowland, S.J., B.Sc.)

Early in March the observatory lost the services of Father O'Connor, who was withdrawn to assume the duties of Rector of the College, to which post he was formally appointed in June, when the present Director was appointed to succeed him. Father J. F. Fleming, S.J., joined the staff of the observatory in September, and otherwise the staff remains as before.

In June the wooden roof of the dark room attached to the underground magnetic chamber was replaced by a concrete roof, and the whole roof of the underground premises was covered with rock asphalt, in place of the lead sheeting, which had become cracked and leaky through age.

Owing to the above-mentioned changes of staff, and absences of members through illness, the routine work of the observatory has been maintained with some difficulty, but the only notable interruption was that the absolute measures of magnetic horizontal force and inclination were omitted in October, and the values for this month are derived only from the continuous photographic records. The meteorological, magnetic and seismological records have been maintained, and the results forwarded to the official centres. A daily synoptic weather-chart has been prepared from data received by wireless telegraphy, and a local daily weather forecast has been supplied to the *Lancashire Daily Post*—a service which has come to be much appreciated in the district.

Observations of the solar surface were obtained on 267 days and show a progressive decline in solar activity. Magnetic activity, on the other hand, shows a slight increase on the previous year. The variation in solar and magnetic activity for the past three years is shown in the following table:—

	Solar		Mean Area (1/5000 of disc)	Magnetic Mean Daily Range	
	Days of Observation	Spotless Days		Decl.	H.F.
				′	γ
1930	266	4	2·26	16·9	88·7
1931	257	36	1·26	13·8	59·5
1932	267	104	0·79	14·4	62·8

As in former years, by an interchange of copies of drawings with Professor Brunner of Zürich, most of the gaps in our observations have been filled, the few remaining days being made good from drawings kindly put at our disposal by Professor G. Favaro of Catania. Sunspot statistics have been sent quarterly to Professor Brunner for the preparation of "Sunspot Numbers" and International "Solar Character Figures."

The number of earthquakes recorded during the year was 82, as compared with 87 in the previous year.

Sixteen lunar occultations were observed, including nine of the Pleiades between 1 a.m. and 4 a.m. on August 24, and the results sent to Dr. Comrie. Observation on many other occasions was prevented by bad weather, which

also prevented any observation of the lunar eclipse on September 14, and of the Leonids in November.

In July the observatory received a valuable donation from Mr. E. T. Whitelow, F.R.A.S., of Birkdale, who presented us with the whole of his astronomical equipment, comprising a wooden observatory with 14-foot dome, an equatorial mount with Cooke driving clock, carrying a principal telescope with $7\frac{1}{3}$-inch O.G. by Alvan Clark (formerly in the possession of the Rev. W. R. Dawes), and two auxiliary telescopes of 5-inch and $3\frac{1}{2}$-inch aperture by Cooke, and a large amount of subsidiary apparatus, much of it specially designed for photography of sunspots, a branch of work in which Mr. Whitelow had specialized. The death of Mr. Whitelow on November 4, so soon after making us this valuable gift, is to us a matter of deep regret.

It has not yet been found possible to re-erect this equipment, but it is hoped to do so at an early date.

Dominion Observatory, Ottawa, Canada
(*Director, Mr. R. Meldrum Stewart*)

Meridian Work and Time Service.—In the regular programme of the meridian circle there were obtained, on 190 observing days, 2099 observations for right ascension and declination of stars, and 212 of the Sun, Moon and planets. On 34 nights observations for clock correction were made with small transits, in November and December the Cooke and Heyde transits being used on alternate nights. The time service was maintained as in previous years, with no material changes. Wireless time-signals were received from Rugby, Annapolis, Bordeaux and Nauen, the receipt being made regularly by the method of coincidence by extinction, and also by automatic registration for about 60 per cent. of the signals. Time-signals were broadcast at noon daily, except Sunday, through CNRO on concert wave-length, and daily through the observatory station on wave-lengths of 90, 40·8 and 20·4 metres.

Solar Physics.—Measurements of tree-growths and analyses of records were continued in the investigation of the astronomical cycles in the climate and forms of life in Canada. Over 80 solar photographs and 115 nine-strip spectrograms of various points on the Sun with iodine absorption spectra were secured; and over 220 spectrograms were measured and reduced. The usual programmes of solar spectroscopy and photography were somewhat curtailed by plans and preparations for observing the eclipse of August 31. A site was occupied a mile west of the central line of totality, northwest of St. Alexis des Monts, Quebec. Two 20-inch cœlostats supplied light to cameras and spectrographs. Motion-pictures of corona and flash spectra were to be accompanied by chronographic recording of the times, and other photographs of the corona and spectrum were planned. Clouds prevented observations.

The 15-inch Equatorial.—Work with this instrument during the year was almost entirely photometric. The photo-electric photometer mentioned in last year's report is now in efficient working order, and appears to be capable

of giving first-class results. Light-curves of ζ Geminorum, η Aquilæ and δ Cephei were determined; some work was also done on 12 Lacertæ, α Canum Venaticorum and η Aurigæ. As in previous years, the telescope was made available to visitors every clear Saturday evening.

Photographic Photometry.—Observations were continued on the Cepheid fields of the international programme, over sixty plates being obtained for the determination of the magnitudes of comparison stars. Sufficient plates have now been secured for forty fields, and all plates have been prepared for measuring. Towards the close of the year a photometer for measurement of the densities of star-images was delivered, and it is hoped to begin soon the measurement of the magnitudes of the comparison stars.

Seismology.—During the year 392 earthquakes were registered at the Ottawa station, and of this number 16 were reported to the Press and 18 to Science Service at Washington, D.C. The dates of occurrence of the largest earthquakes recorded and the districts affected by them are as follows: 1932 June 3, Mexico; 1932 June 18, Mexico; 1932 July 7, Lower California; 1932 December 21, Nevada. The seismographs at Ottawa, Halifax, Saskatoon, Shawinigan Falls and Seven Falls were maintained in practically continuous operation throughout the year. An investigation of the Tango earthquake of 1927 March 7 was completed, resulting in new and improved travel-time curves for longitudinal and transverse earthquake waves.

Terrestrial Magnetism.—Owing to restricted appropriations, field-work was confined to the determination of the three magnetic elements at two stations where special declination observations were made at the time of the total solar eclipse on August 31. Other observational work comprised the yearly redetermination of the elements at Ottawa and the usual inter-comparison of instruments. In the office progress was made in the reduction to epoch of all observations made since the inauguration of the systematic survey in 1907.

Gravity.—Reductions for the complete list of 129 Canadian gravity stations were completed by the Hayford method and also under certain assumptions based on the Airy hypothesis. It was found that such reductions, when numerous, were facilitated by special maps showing the average elevation, by sections, of the areas involved. Such a map covering North America and the adjoining oceans was prepared. An investigation of the cause of the large anomalies in the deflection of the vertical in the vicinity of Gaspé was made, and a report on the subject will appear in the near future.

Applied Geophysics.—In continuation of the work of 1930 and 1931, magnetometric surveys for the purpose of investigating the relation between the anomalies and the occurrence of the minerals asbestos and chromite were made in the serpentine belt in the vicinity of Thetford, Quebec. Magnetometric traverses were also made of the Stony Creek gas and oil field in New Brunswick and of the Malagash salt deposit in Nova Scotia.

Publications.—Publications during the year included four numbers of the regular series of Publications of the Dominion Observatory, namely,

Vol. x, Nos. 12, 13, 14 and 15, *Bibliography of Seismology*. Other papers published elsewhere or issued in mimeographed form included the following: Wireless Time-signals Observed at Ottawa, 1927–1931; Magnetic Results, 1927–1931; Standard Time and Time Zones in Canada; The *P*-curve and the *S*-curve Resulting from a Study of the Tango Earthquake, Japan, 1927 March 7; Sunspots and Forest Fires; The Projection of Circles on a Mercator Map; The Earthquake of October 1931 in the Solomon Islands; Surveys with the Torsion Balance and the Magnetometer in Eastern Canada.

Dominion Astrophysical Observatory, Victoria, B.C.
(Director, Dr. J. S. Plaskett, F.R.S.)

The staff of the observatory has remained unchanged throughout the year. Professor J. S. Foster and Dr. A. Vibert Douglas were engaged as voluntary observers during June and July in obtaining spectra, with the highest dispersion (7 A. per mm.), of several B-type stars for the purpose of investigating the Stark effect in stellar spectra.

The observing weather during the year has been considerably below the average; 1137 hours on 193 nights, as compared with the fourteen-year average of 1256 hours on 204 nights. This was mainly due to an abnormally wet July, the wettest in sixty years, and a cloudy August, which are usually the two best months. Against this was the best September since observations commenced. The number of spectra obtained, 711, is about 25 per cent. less than last year and just half of the fourteen-year average of 1424, the reduction being due to the observation of fainter stars. In addition over a hundred direct photographs of globular clusters were made for the study of contained variable stars.

An event of the year was the visit to the observatory of a party of twenty astronomers, mainly from England, on their way to the total solar eclipse and I.A.U. meeting, to which Messrs. Plaskett, Harper and Beals from this observatory were representatives.

The Director and Dr. J. A. Pearce, in collaboration, have continued the discussion of the radial velocities of the O to B5 stars, which have been under investigation since 1923. All the work on these stars is to appear in Vol. 5 of the Observatory publications. No. 1 and No. 2 of Vol. 5, containing the observations made at Victoria and a general catalogue of all known velocities, respectively, have been distributed. Vol. 5, No. 3, on the motions and distribution of the interstellar diffuse matter from 314 stars, has gone through the last proof, is now being printed and will be distributed early in the year. The main results of the discussion of the radial velocities and proper motions of the 1010 O and B-type stars will be contained in Vol. 5, No. 4—"The Motions of the O to B5 Stars." The mean parallaxes of thirteen type and magnitude groups of these stars have been obtained, and a general solution of the solar motion and K term for the whole group and of the two components of the galactic rotation for four type and magnitude groups, with normal equations of eleven unknowns, has been completed with

interesting and satisfactory results. It is hoped to complete this work and send it to the printer during the year.

Mr. W. E. Harper has continued observations on the A-type programme, adding a few stars in the summer region of the sky. During the year 336 spectra were obtained and 380 measured for radial velocity. A study of the line residuals of 400 stars of A-type was carried through for deriving the best values of the wave-lengths to be used in determining radial velocities, and a table of such values was prepared for the Radial Velocity Commission of the I.A.U. It is the purpose to complete the radial velocities of all H.R. stars and prepare a general catalogue before proceeding with the discussion of the absolute magnitudes. In addition, orbits were determined for three binary systems: H.R. 976, H.R. 1528 and H.R. 6290 now in press.

Dr. J. A. Pearce, in addition to collaborating with the Director in the work on the motions of the O and B stars for Vol. 5, has continued his observations of the fainter B-type stars and of double-lined O and B-type binaries, and has completed the determination of the orbital elements and the minimum masses of nine double-lined binaries. The H.D. numbers of these binaries with the spectral type and the minimum masses of the systems are as follows: H.D. 698, B9sek, 158·1⊙; H.D. 57060, O7sfk, 56·5⊙; H.D. 208095, B7, 34·4⊙; H.D. 39698, B3k, 14·2⊙; H.D. 29376, B3k, 10·7⊙; H.D. 44701, B5n, 10·3⊙; H.D. 218440, B3sk, 7·7⊙; H.D. 57103, B8, 6·6⊙; H.D. 199628, B9n, 1·8⊙. The last star is an eclipsing variable of the β-Lyræ type, while the spectroscopic elements of another eclipsing system of Algol type H.D. 93033, B9, have also been determined. H.D. 698, of which a preliminary mass of the system of 174 times the Sun was announced in last year's report, has had additional plates obtained with final elements reducing the mass to 158 times the Sun. It is the most massive system known, and is of further special interest as the first star later than B5 to show interstellar calcium lines.

Dr. C. S. Beals has continued the observation of interstellar calcium and sodium lines, and has practically completed the programme of observation of the Wolf-Rayet stars. With the help of Mr. S. N. Hill, the contours and total intensities of a considerable number of Wolf-Rayet emission bands have been measured spectro-photometrically. The measures of total intensity have been employed to obtain the temperatures of Wolf-Rayet stars and novæ by an application of Zanstra's theory of nebular emission. The results indicate temperatures from 55,000° to 75,000° for the Wolf-Rayet stars, of 65,000° for Nova Aquilæ and 25,000° for P Cygni. A considerable amount of time has been spent in collecting and analysing reports of auroral observations in Northern Canada. The material at hand seems to indicate the presence of luminous and audible effects at low levels during occasional auroral displays.

Dr. Frank S. Hogg has made a number of spectrograms of the brighter planetary nuclei. Owing to the faintness of these objects the dispersion that can be used is small, 90 A. per mm., and many of the exposures are very long. These plates are being studied for the determination of parallax from interstellar calcium, for possible Einstein displacements, and for general

comparison with ordinary stars of the same spectral classes. Plates for spectro-photometric analysis have been made of the long-period variable χ Cygni and the irregular variable Z Andromedæ. Over a hundred photographs of globular clusters have been made at the Newtonian focus of the 72-inch, in collaboration with Dr. Helen B. Sawyer, who is studying the variable stars in several clusters.

Mr. S. N. Hill has measured 82 spectra for radial velocity, including 58 of Z Ursæ Majoris for the relationship between velocities at maximum and minimum light. He has done a great deal of computational work on least-square solutions, prepared many graphs and charts for various purposes, and assisted in the photometric measurement and reduction of the Wolf-Rayet spectra.

During the year Vol. 6, No. 5, has been printed and distributed, and Vol. 7, Nos. 7, 8 and 9, are in press ; Vol. 5, No. 1 and No. 2, distributed, while Vol. 5, No. 3, is now being printed. Several articles in astronomical periodicals have appeared during the year, and the weekly seminars are being continued.

Helwan Observatory, Ministry of Public Works, Egypt
(*Director, Mr. P. A. Curry*)

Time Service.—The time service was maintained as usual, the error of the standard clock, Shortt No. 1, being determined daily from the Bordeaux and Rugby rhythmic time-signals. On July 5 the clock case of the free pendulum developed a fairly rapid leak. The trouble was eventually traced to the surfaces of the brass flanges at the two ends, and these were carefully reground, but it was not until August 12 that the Shortt clock could be taken over as standard again. Since then it has run very satisfactorily, the leak being completely cured. While the Shortt clock was under repair, the Riefler clock was used as standard and behaved well.

The reversible transit was used occasionally. The level bubble has been remounted in the Physical Department workshops and is now giving satisfactory results. It is hoped that a high standard of transit observations will be obtained during the International Longitude determinations in 1933.

Reynolds Reflector.—The telescope was used on 65 nights, 66 plates being exposed on nebulæ, comets and for focus. The results of the reduction for the position of Comet Peltier Whipple were communicated to the B.I.A.U.

General.—The usual meteorological, magnetic, seismological and solar radiation observations were continued.

Observations of the Leonids were made on November 16, 17 and 18, and a short account of these was communicated to the Society.

Bulletin 35 on the Installation of the Schuster-Smith Magnetometer was published during the year. Bulletin 36 on the Choice of a Suitable Projection for the Celestial Hemisphere is in the press.

Nizamiah Observatory, Hyderabad
(*Director, Mr. T. P. Bhaskaran, M.A.*)

The programme of work with the astrographic telescope remained the same as in previous years. The number of plates obtained was 110; of these, 87 plates were taken for the catalogue in the zones $+36°$ to $+39°$, while the remainder were exposed in the Hyderabad zones for comparison with the earlier plates taken here about twenty years ago. 45 catalogue plates have been measured and also 5 repetition plates for the determination of proper motions. Steady progress has been made with the measurement of the Eros photographs obtained during the opposition of 1931, and it is hoped the work will be completed early in 1933.

A blink comparator, made according to Professor Schlesinger's design, has been added to the equipment of the observatory.

The MS. of the catalogue zone $+39°$ is ready for the press, and a start has been made with the preparation of the MS. of the catalogue zone $+38°$. The publication of the measures will be taken in hand as soon as the arrangements for printing are complete.

The 15-inch Grubb refractor was used as usual for the observation of some long-period and irregular variables; and 1208 estimates of visual brightness have been obtained.

Sixteen occultations of stars by the Moon were observed: Disappearances, 12; Reappearances, 4. Observations with the transit instrument were made occasionally for the determination of clock errors.

The Milne-Shaw seismographs (both components) have been operating satisfactorily, and 100 earthquake shocks were registered during the year. The readings of the principal phases of the seismograms are being communicated to the University Observatory, Oxford, for incorporation in the *International Seismological Summary*.

Daily observations of the upper air by means of pilot balloon flights have been continued in co-operation with the India Meteorological Department.

The meteorological observations and other routine duties of the observatory have been carried on as in previous years.

Kodaikanal Observatory
(*Director, T. Royds, D.Sc.*)

Dr. Royds was absent on leave from 1932 March 30 to 1932 December 14, and Dr. K. R. Ramanathan, M.A., D.Sc., acted as Director during the period.

Photoheliograms were obtained on 342 days, calcium flocculi plates on 335 days, calcium prominence plates on 309 days, *Hα* flocculi plates on 291 days, and *Hα* prominence plates on 264 days. One calcium flocculi plate for each day was sent to the Solar Physics Observatory, Cambridge, as in former years.

Under the auspices of the International Astronomical Union, prominence

and *Hα* flocculi spectroheliograms were collected from other observatories whenever complete observations were not possible at Kodaikanal. The statistical data regarding prominences seen at the limb and by absorption on the disc are published in half-yearly bulletins.

Daily character figures of solar activity according to *Hα* bright flocculi and *Hα* dark markings have been communicated to the Observatoire Fédéral, Zürich, for publication. In addition, character figures for the period 1918 to 1922 were also derived and supplied on the request of Professor Brunner. Daily character figures for calcium flocculi from Kodaikanal photographs are furnished by the Solar Physics Observatory, Cambridge.

The Milne-Shaw seismograph was brought into use from 1932 January 15.

The Riefler clock of the Madras Observatory has been transferred to Kodaikanal.

The research work carried out is indicated by the following publications contributed by the staff during the year :—

"Prominences and Radiation Pressure," by T. Royds, *Kodaikanal Observatory Bulletin*, No. 95.

"The General Spectrum of the Night Sky Radiation," by K. R. Ramanathan, *Indian Journal of Physics*, 1932.

"Two Longitudinal Zones of Apparent Inhibition of Sunspots on the Solar Disc," by P. R. Chidambara Iyer, *Kodaikanal Observatory Bulletin*, No. 97.

"Two Longitudinal Zones of Apparent Inhibition of Sunspots on the Solar Disc" (2nd paper), by P. R. Chidambara Iyer, *M.N.*, 1932 December.

"The Structure of *Hα* Absorption Markings on the Sun," by P. R. Chidambara Iyer, *Current Science*, Bangalore.

"The Variations in Area of Hydrogen Absorption Markings with Longitude," by Md. Salaruddin, *Kodaikanal Observatory Bulletin*, No. 96.

"Further Investigations of the Arc Spectrum of Arsenic," by A. S. Rao, *Proc. Roy. Soc. London.*

"A Note on the First Spark Spectrum of Arsenic," by A. S. Rao, *Current Science*, Bangalore.

"A Note on the Nuclear Spin Moment of the Thallium Atom," by A. S. Rao and A. L. Narayan, *Current Science*, Bangalore.

"A Thesis on the Investigations of the Arc and Spark Spectra of Arsenic," by A. S. Rao, Thesis submitted to Madras University.

"A Note on the Nuclear Spin of Arsenic," by A. S. Rao, *Current Science*, Bangalore.

"The Resonance Spectrum of Hydrogen," by K. R. Rao, *Nature.*

"Summary of Prominence Observations for the First Half of 1931," *Kodaikanal Observatory Bulletin*, No. 94.

"Summary of Prominence Observations for the Second Half of 1931," *Kodaikanal Observatory Bulletin*, No. 98.

The Leonid showers were looked for on the nights of November 16 and 17, but were not seen. Dr. Narayan has photographed some absorption and emission lines in the nickel spectrum for photometric study.

Union Observatory, Johannesburg
(Union Astronomer, Mr. H. E. Wood, M.Sc.)

26½-inch Grubb Visual Refractor.—The year's work comprises :

Photographs of Double Stars—78 plates with multiple exposures.
Saturn's Satellites—20 measures.
Double Stars—2892 measures of double stars (including the 9-inch measures).

Franklin-Adams Star Camera.—During the year, 539 plates were taken with this instrument, distributed as follows :—

Short-Focus Lens	Minor planet regions and star maps ...	317 plates.
	Variable star regions	30 ,,
	Comets	158 ,,
Long-Focus Lens	Photometric plates	39 ,,

Comet 1932 *b* (Houghton-Ensor) was photographed from 1932 April 2 to May 7.

Comet 1932 *e* (Kopff) was searched for from March 7 but not found until 1932 May 26, after which it was observed to 1932 November 16.

Comet 1932 *g* (Geddes) was observed from 1932 June 23 to September 25.

Comet Tempel 1 was unsuccessfully searched for on November 26.

Comet 1932 *n* (Forbes-Dodwell) was observed from December 17 and was under observation at the end of the year.

309 measured positions of minor planets have been forwarded to the Astronomisches Rechen-Institut.

Occultations of Stars by the Moon.—The programme of the last few years has been maintained without alteration, and 143 occultations were observed during the year.

The results of the year's observations are as follows :—

	s	″
1932·1	9·7	5·3
·3	11·1	6·1
·6	10·0	5·5
·8	8·6	4·7

The second column indicates the time by which the Moon has arrived too early at any longitude, and the third column the distance the Moon is ahead of its tabular longitude.

A number of occultations, observed by Mr. G. E. Ensor of Pretoria, has been reduced and the results forwarded to Professor E. W. Brown.

Union Observatory Circulars.—During the year Circulars Nos. 86, 87 and 88 were distributed. Twenty-four southern star maps were issued with these circulars. Zones $-22°$, $-28°$, $-34°$ and $-40°$ are now completed.

The present state of the project is as follows :—

Maps already issued	447
Maps in hands of Government printer	15
Maps still to be prepared	94
Total	556

Miscellaneous.—The Union Astronomer was on leave from July 18 to November 6, and attended the meeting of the International Astronomical Union at Cambridge, U.S.A.

The number of visitors to the observatory during the year has been 1163.

Sydney Observatory
(*Director, Mr. James Nangle, Government Astronomer*)

Work in connection with the preparation of the Astrographic Catalogue for the Sydney zones was carried on as usual. Two volumes, Numbers IX and X, were placed in the hands of the printer, and the printing of these was very nearly completed by the end of the year. Copies of these volumes should be ready for distribution early in 1933. The work of removing the Astrograph from Pennant Hills back to the Sydney Observatory was completed during the year. The Time Service was carried on satisfactorily. Information necessary for civil purposes was supplied as required throughout the year. One hundred and thirty records of earth tremors were obtained, ten of the records being of intense disturbances. Seismological bulletins were distributed monthly to neighbouring seismological stations. Public interest was sustained during the year, there being no less than 1970 visitors to the observatory. The buildings and equipment of the observatory are in excellent condition. Fortunately nothing further has been heard of the proposal made some time ago to close the Sydney Observatory. The staff remains as before.

Adelaide Observatory
(*Director, Mr. G. F. Dodwell, B.A., Government Astronomer*)

The usual routine work, described in previous reports, has been continued. Latitude variation observations with the zenith telescope supplied by Dr. Kimura, President of the International Latitude Commission, were continued throughout the year, the observers being Messrs. A. L. Dawson, B.Sc., and A. E. Markey. 701 pairs of latitude stars were observed on 69 nights, and the results of the observations were sent to Dr. Kimura at Mizusawa Observatory, Japan.

A course of lectures on astronomy for surveyors was given at the Adelaide University by the Director.

As the financial position was somewhat easier than last year, it was possible to continue some of the magnetic field work, and observations were made in the Kadina mining district and at stations on the south coast.

A four-inch equatorial telescope with excellent driving clock and circles was purchased in December from the estate of the late Mr. E. Farrow, and suitable housing is being provided for it in the Observatory grounds. It is intended to use this instrument, with a wide angle camera attachment, for photographic work.

In December a photographic search was made for Tempel's Comet in and near the region indicated by Dr. Crommelin's search ephemeris, and in the course of this search a comet was discovered on December 16 in R.A. $22^h\ 59^m$, Dec. 29° 30′ S.

Commonwealth Solar Observatory, Canberra, Australia
(*Officer-in-Charge, Mr. W. B. Rimmer*)

Solar Radiation.—Attention has been given to the decrease in the intensity of solar radiation arriving at the Earth's surface since the beginning of May. This appears to have been due to an increase of atmospheric turbidity resulting from the volcanic dust transferred to the atmosphere during the eruptions in April in the South American Andes. This diminution of approximately 4 per cent. was fairly uniform until December, when there were indications of a return to normal values.

Sun Telescope.—Tests of the mechanical and electrical parts of this instrument have proved satisfactory, and the polar axis of the cœlostat mirror has been carefully adjusted. An electrically operated slow-motion device has been designed and fitted to the second mirror, thus enabling a fine adjustment of the image to be made. A complete atlas of the Sun's spectrum over the region 3650–8000 A. has been photographed, using the three-prism spectrograph ; twenty-eight exposures were necessary to cover this region.

A research on the intensities and contours of the Fraunhofer lines in the solar spectrum has been commenced and some preliminary results obtained. Microphotogram traces over the region 4358–5766 A. have been made from a series of plates, each of which has been photometrically standardised by a slit-width variation method. From the traces the percentage absorption in the centre of the lines has been measured for about two thousand Fraunhofer lines. Means of correcting for photographic defects and the finite resolving power of the spectrograph are under investigation. A study of the relations between central-line intensity, Rowland intensity, equivalent breadth, multiplet designation, excitation potential, etc., has been commenced.

Atmospheric Electricity.—Observations of the electrical conductivity of the atmosphere, air-earth current, together with concentrations of nuclei and small ions, have been continued. Special series of observations of the mean life-period of the small ions, and of the charges carried by the intermediate and large ions, have been made. The results of these observations are being prepared for publication. Apparatus for the measurement of the

intensity of highly penetrating radiation has been constructed and is being developed.

Atmospherics Investigations.—Charts from the continuous recorder have been obtained daily throughout the year and observations with a cathode ray direction-finder have been made three times weekly. The sources of atmospherics have been classified as regular and irregular. The former are in the tropical areas of great thunderstorm activity, while the latter, when they occur within or near the Australian continent, are found to be associated with barometric depressions. The early detection of areas of low barometric pressure by the associated atmospherics has allowed of more accurate weather forecasting, particularly in Victoria and Tasmania.

The Reynolds Telescope.—An observer's carriage adaptable to all positions of the telescope, and also the necessary silvering gear, have been constructed in the observatory workshop. The mirrors were resilvered in December, and final adjustments to the instrument are being made.

Publications.—Two papers on spectroscopic researches have been published in the *Physical Review* (pp. 42–63, vol. 39, No. 1, 1932). Other papers are in preparation.

General.—The programme of work, as outlined in last year's report, has been continued. The observatory has been regularly open to the public, and demonstrations both by day and by night have been given to various large parties.

Melbourne Observatory
(*Director, Dr. J. M. Baldwin, Government Astronomer*)

Work has proceeded as well as the depleted staff and further reduction in the grant would permit.

The regular observation of the list of Fundamental Stars published in the *Connaissance des Temps* for 1914 with the 8-inch transit circle, and of southern long-period variable stars with the 8-inch equatorial has been continued. The latter observations have been published regularly in *Popular Astronomy*.

The measurement of the Eros plates for parallax is proceeding, but only a limited amount of time is available for this work.

Lack of funds has prevented any progress in the printing of the fourth and fifth Melbourne *General Catalogues* or of vols. iv and v of the *Astrographic Catalogue*. Magnetic and seismological work has been carried out as in previous years. Seismological bulletins have been issued quarterly, but the hourly values of the magnetic elements could not be published.

The time service has been improved by bringing the mean time clock under the control of the Shortt free-pendulum (sidereal) clock. The arrangement permits of the automatic comparison of the two clocks at regular intervals, which can be varied to allow for the rate of free-pendulum clock. At each comparison a small weight is automatically raised from, or lowered on to, a platform on the pendulum of the mean time clock, which is thus made to lose or gain until the next comparison, about 366 seconds later.

The Dominion Observatory, Wellington, New Zealand
(*For the Year* 1931)

(*Director, Dr. C. E. Adams, Dominion Astronomer and Seismologist*)

The time service has been maintained, and the regular daily signals transmitted. The total number of signals sent from the observatory was 2295. The usual method of recording radio time-signals has been to use the chronograph with the hand key. 718 signals on 5 call-signs were received, including both mean time and rhythmic signals. It has not been possible to make much use of the British time-signals from Greenwich Observatory, transmitted by Rugby radio, owing to the very unsuitable times of transmission at 9.30 p.m. and 5.30 a.m. N.Z.M.T.

Occultations.—With the assistance of members of the New Zealand Astronomical Society resident in different parts of the Dominion, observations have been made of occultations of stars by the Moon, and the results forwarded to Dr. L. J. Comrie.

Sunspots.—Observations of the Sun are made whenever possible with the 5-inch Grubb refractor of the Wellington Philosophical Society, and the results have been sent to Zürich where they are used for international work in the determination of Wolf-Wolfer relative sunspot numbers.

Solar Parallax Programme.—In response to a request from Dr. H. Spencer Jones, the 9-inch telescope was used during January and February for taking photographs of the planet Eros. Owing to extremely poor weather conditions at the time, only 18 plates could be attempted, and the planet was identified on 6 of these. This work was undertaken by members of the New Zealand Astronomical Society in conjunction with the staff of the Dominion Observatory.

Encke's Comet.—Visual observations of Encke's comet were made with the 9-inch telescope on July 5, 16 and 17, and circle readings obtained of the positions. The results were forwarded to Dr. Crommelin.

Seismology.—During the year 1295 earthquakes were recorded on the seismographs. The total number of earthquakes felt in New Zealand was 431, 228 of these being felt in the North Island, 225 in the South Island, while 21 were felt in both Islands.

The outstanding seismic feature of the year was the disastrous earthquake on 1931 February 3. The epicentre of this earthquake was located on the coast-line of Hawkes Bay, from 5 to 15 miles north of Napier, while a detailed study of the seismograph records indicated that the seat of the disturbance was from 10 to 15 miles beneath the earth's surface. The main shock was felt over practically the whole Dominion.

A number of earthquake stations were established in various parts of the Dominion as follows: Milne seismograph at Arapuni, Imamura; Strong Motion seismograph at Takaka; Wood-Anderson seismograph at New Plymouth; Milne-Jaggar shock recorder at Hastings; and Mr. C. J. Westland supplied records from his private station at Christchurch. As a result earthquake epicentres can now be determined with greater precision, and an

indication of the focal depth of the more important earthquakes can usually be obtained.

Mr. R. Barker's Observatory, Cheshunt, Herts

The 12″·6 Calver Equatorial Clock-driven Telescope has been employed for observations of the Moon, Venus, Saturn and the satellites of Uranus and Saturn. Variations in the light of Oberon, Titania, Rhea, Dione and Tethys were recorded.

Mr. A. F. Bennett's Observatory, Leiston, Suffolk

The 6-inch refractor and spectroscope have been used on the Sun as in previous years. Visual observations of other objects and the search for expected comets have been also carried out with the refractor. Some plates have been exposed in the two star cameras in the course of this and other work. Tests on new types of photographic plates have enabled exposure times to be reduced as compared with those necessary with plates previously used.

Comet Peltier-Whipple was observed on many occasions, but the search for Tempel 2 was hampered by extremely bad seeing conditions.

The partial eclipse of the Moon on 1932 September 14 was observed under very good conditions. Four occultations of stars by the Moon were obtained, other attempted observations being prevented by cloud.

Rev. T. E. Espin's Observatory, Wolsingham

The work of measuring some known double stars and of searching for new double stars and measuring them with the 24-inch and 17¼-inch Calver reflectors has been continued, and the results communicated to the Society.

Mr. Evershed's Observatory, Ewhurst, near Guildford

Spectroheliograms in $H\alpha$ light have been taken when definition was good for the estimation of character figures and to supplement the Kodaikanal series.

The research on the rotation velocity of the prominences has been continued, but not many spectra have been secured, mainly owing to the infrequency of large prominences and their low density during this phase of the solar cycle. This entails very long exposure times both for the H and K lines and $H\alpha$.

The liquid prism spectrograph has been employed in photographing east and west limb spectra simultaneously by a new method, and accurate measures of the rotation velocity especially in the D and *b* regions of the spectrum have been made. Limb spectra have also been obtained with comparison spectra of the iron arc, for measuring the limb shifts of stable iron lines in the region between λ 4100 and λ 4300.

Owing to illness no work was possible during the last three months of the year.

Mr. F. J. Hargreaves's Observatory, Kingswood, Surrey

Observations of the physical features of Jupiter were continued and nearly 1500 central-meridian transits of markings were timed during the apparition which ended in June. A few observations have already been made in the new apparition.

Measurements of double stars with the micrometer described in *M.N.*, **92**, 1, have been continued, and the writer is now satisfied that the superiority of this instrument over the filar micrometer for the measurement of position angle is as great as, if not greater than, for separation. The advantage is more marked, the closer the stars, down to 0″·5. Many of the pairs measured in 1931 were remeasured in 1932, and the agreement is satisfactory. With one exception, changes in position angle outside the range of accidental error have been in accordance with published ephemerides.

The polar and equatorial diameters of Jupiter were measured on the night of 1932 February 7 with a modification of this instrument in which the artificial stars are replaced by an artificial disc of variable angular subtense. The measures have not yet been reduced, but it may be said that the ratio of the two diameters is 1·073, as compared with the accepted value of $\frac{15}{14}$, or 1·0714. Twenty-four settings were made, and the mean deviation was of the order of 0″·06.

Only four occultations of stars by the Moon were timed; the remainder of those predicted for Greenwich in the *Nautical Almanac* were obscured by clouds at Kingswood.

Mr. Newbegin's Observatory, Worthing, Sussex

The usual routine work on prominences and sunspots has been carried out, and 132 observations for prominences and 150 for sunspots have been made. The mean daily frequency for the former works out at 7·46 and for the latter 1·14. Fifty-one days were spotless.

Full details of the results may be found in the *Journal of the B.A.A.*, **42** and **43**.

A spectrohelioscope is under construction in the workshop to designs kindly furnished by Dr. G. E. Hale.

Mr. B. M. Peek's Observatory, Solihull, Birmingham

The usual programme has been continued.

The most important result of the year's work has been the detection and confirmation of the evidence, in collaboration with Rev. T. E. R. Phillips and Mr. F. J. Hargreaves, of a circulating current in the S. Tropical region of the planet Jupiter.

The Rev. T. E. R. Phillips's Observatory, Headley, near Epsom

The usual programme of visual work on the planets and double stars has been continued.

Dr. Waterfield's new photographic equipment referred to in the last report has been installed. Some delay was caused by the necessity for returning the 6-inch triplet and camera to the makers for certain alterations. Trial plates are now being taken, and it is hoped to start systematic work very shortly.

Both observers were away during part of the summer for the solar eclipse on August 31. Mr. Phillips afterwards attended the meeting of the I.A.U. at Harvard.

A paper by Dr. Waterfield on the Eclipse Expedition to Gorham, New Hampshire, has been communicated to the Society.

During the year the 26th Report of the Jupiter section of the B.A.A., dealing with the apparition of 1927–28, was prepared and published.

Dr. W. H. Steavenson's Observatory, West Norwood

Observations were made on 124 nights.

The 20-inch Hindle reflector continues to be used chiefly for photometric work.

105 observations of 8 novæ were made during the year, and some of the results have already been communicated to the Society.

433 observations of 28 irregular and long-period variables were also made, and the results have been sent to the Director of the Variable Star Section of the B.A.A.

A beginning has been made in the revision and extension of certain sequences of faint stars for use by variable star observers. This work is being done in collaboration with Professor S. A. Mitchell in accordance with a scheme agreed upon at the recent meeting of the I.A.U.

The comets Houghton-Ensor, Carrasco, Grigg-Skjellerup, Newman and Peltier-Whipple were each observed for position on several nights and the measures communicated, as soon as made, to the I.A.U. Bureau at Copenhagen.

Similar observations were also made of the two interesting minor planets discovered, respectively, by Delporte and Reinmuth.

Some photometric observations were made on the outer satellites of Uranus and on the planet Pluto, but these have not yet been reduced.

A new photometer, made by Mr. H. J. Quilter, has been brought into use this year. Particulars of its construction are given in *M.N.*, **92**, 8.

A simple tape-chronograph, made and presented by Mr. W. T. Hay, has also been installed in the observatory, and has been found very useful in the observation of occultations and for measurements of the positions of comets and minor planets.

The tube of the 20-inch telescope was remodelled by Mr. Hindle in September, and the mirrors were resilvered in March and October.

Mr. Tomkins's Observatory, Dedham, Essex

The 24-inch Cassegrain Reflector has again been in use whenever possible during the year, and the 6-inch Cooke refractor has proved its value for guiding to secure photographs of the Moon. The examination of the plates already taken has been carried on, and the relative ages of a good number of the formations have been estimated.

An infra red plate was exposed to the lunar eclipse on 1932 September 14 through a suitable filter, with an exposure of 18 seconds, in order to ascertain whether any sign of the very bright red eclipsed portion of the lunar disc could be obtained. The result was negative.

An Astra plate used with an orange filter and two seconds exposure gave a fair picture in spite of slight haze.

A 30-inch glass disc which has been awaiting grinding has now been mounted on the grinding machine and the work of grinding begun. The disc is proving a good one, and the curve has reached a diameter of about 21 inches and a depth of about $\frac{3}{32}$ inches, giving evidence so far of good material. The machine used for the 24-inch has been adapted for the work.

The present cell of the Cassegrain telescope will accommodate the new 30-inch speculum without alteration except that a larger, but not longer, tube will be required. Very little work beyond the making of the mirror will therefore be necessary to secure considerable increase in power for the instrument.

NOTES ON SOME POINTS CONNECTED WITH THE RECENT PROGRESS OF ASTRONOMY

Minor Planets

One hundred and eighty-eight planets were discovered in 1932. The method of tabulating the discoveries has been abbreviated. The first letter of the planet's designation gives the date of discovery within half a month: the first letters for the successive half-months are AB, CD, EF, GH, JK, LM, NO, PQ, RS, TU, VW, XY. AB corresponds to January, CD to February, and so on.

S. Arend (Uccle) CF, EE, MA; E. Delporte (Uccle) CB, CC, CG, DC, DD, DE, EA, EB, EC, EA_1, FA, LA, NA, RL, SA, WA, WB, WC, WD, WE, YA, YP; J. Hartmann (La Plata) JA; C. Jackson (Johannesburg) EC_1, HL, HM, HN, JD, JE, KD, KE, KF, KG, KH, KJ, LC, MC, NK, OA, OB, OC, PH, RM, RN, RO; G. B. Lacchini (Turin) DA; Madame Laugier (Uccle) QA; Frl. S. Necrassoff (Simeis) UC, UD; G. Neujmin (Simeis) AD, AE, AF, EZ, FC, KB, KC, LB, NB, NC, ND, NE, NF, NG, PA, PB, PC, RO, RP; J. Putilin (Moscow) SB; K. Reinmuth (Königstuhl) BB, BC, BD, BE, BF, BG, BH, BJ, BK, BL, BN, CK, CM, CN, CO, CP, CQ, CR, CS, CT, CU, CV, CW, CX, CY, CA_1, CB_1, CC_1, CD_1, CE_1, EF, EG, EH, EJ, EK, EL, EM, EN, EO, EP, EQ, ER, ES, ET, EU, EV, EW, FB, GA, HA, HB, HC, HD, HE, HF, HG, HH, HJ, JB, NH, NJ, PD, PE, PF, PG, RA, RB, RC, RD, RE, RF, RG, RH, RJ, RK, SC, SD, TB, VA, VB, WE, WF, WG, YB, YC, YD, YE, YF, YG, YH, YJ, YK, YL, YM, YN, YO; G. Reiss (Algiers) UB; F. Rigaux (Uccle) ED; Frau P. Shajn (Simeis) KA; A. Schmidt (Algiers) BA; R. Schorr (Bergedorf) CD, CH; A. Schwassmann and A. Wachmann (Bergedorf) DB; G. van Biesbroeck (Yerkes) CF_1, CG_1; L. Volta (Turin) CA; M. Wolf (Königstuhl) AA, AB, AC, BM, CJ, EX, EY, HK, JC; H. E. Wood (Johannesburg) EB_1.

The following discoveries in earlier years were delayed in publication: 1930 WJ (Delporte); 1931 PH (van Gent); 1931 VA_1 (van Biesbroeck); 1931 YA (Reinmuth). YA is a tenth Trojan planet named Troilus; it is on the side of smaller longitude. There are now five known Trojans on each side of Jupiter. Troilus has the highest inclination, 34°·3, and the greatest eccentricity, 0·197, of any of the Trojans.

The following identities have been established:—

202 Chryseis = 1932 MB; 220 Stephania (missing since discovery in 1881; the suspected identity of 1927 SD with Stephania is disproved) = 1932 UA; 553 Kundry (missing since 1904) = 1932 CL; 627 Charis = 1932 CZ; 705 Erminia = 1895 CDa = 1905 SDa; 811 Nauheima = 1930 SM

(the previously accepted orbit of 811 proved to need considerable correction); 869 Mellena = 1931 RC; 932 Hooveria = 1912 OC; 1135 = Σ56 = 1911 MFh; 1176 Lucidor = 1927 BF; 1181 Lilith = 1914 UD; 1927 TB = 1931 TG_2; 1931 VS = 1931 XH; 1931 WA = 1931 WB = 1931 XD.

681 Gorgo, missing since 1909, was recovered in 1932.

The following planets have received permanent numbers :—

1926 RE = 1931 XG = 1184; 1927 WC = 1185; 1929 PL = 1932 CC = 1186; 1929 XC = 1187; 1930 SB = Σ94 = 1188; 1930 SG = 1189; 1909 FT = 1930 SL = 1190; 1931 CA = 1191; 1931 FE = 1192; 1931 HB = 1193; 1931 JG = 1194; 1931 KD = 1195; 1931 KE = 1196; 1925 AC = 1931 LD = 1197; 1931 RA = 1198; 1931 RF = 1199; 1929 CX = 1931 RH = 1200; 1909 HW = 1916 ZF = 1931 RK = 1201; 1924 TQ = 1931 RL = 1202; 1926 RH = 1931 TA = 1203; 1931 TE = 1204; 1931 TB_1 = 1205; 1931 UH = 1206; 1931 VT = 1207; 1931 YA = 1208; 1927 HA = 1209; 1904 QW = 1927 SK = 1931 LB = 1210; 1931 XA = 1211; 1931 XC = 1212; 1931 XD = 1213; 1932 AA = 1214; 1932 BA = 1215; 1932 BL = 1216; 1925 HC = 1932 EC = 1217; 1932 BJ = 1218; 1932 CJ = 1219; 1932 CU = 1220; 1932 EA_1 = 1221; 1932 LA = 1222; 1931 TG = 1223.

The following planets have been named : 1010 Marlene; 1018 Arnolda; 1048 Feodosia; 1096 Reunerta; 1107 Lictoria; 1115 Sabauda; 1120 Cannonia; 1151 Astronomia; 1155 Aënna; 1164 Kobolda; 1186 Turnera; 1188 Gothlandia; 1193 Africa; 1194 Aletta; 1195 Orangia; 1196 Sheba; 1197 Rhodesia; 1199 Geldonia; 1208 Troilus; 1213 Algeria; 1217 Maximiliana; 1221 Amor; 1222 Tina.

It will be perceived that Nos. 1120 and 1186 are named after the Honorary Member and the late Foreign Secretary of this Society. M. Delporte has stated that he gave the name Maximiliana to No. 1217 in memory of the late Professor Max Wolf, who discovered an immense number of minor planets, and found this one in duplicate, but somewhat later than M. Delporte. No. 1221, another discovery of M. Delporte, was given a name to indicate its companionship with Eros; it approaches the Earth still more closely than Eros.

There is now only one planet in the first 300 that has not been observed since the year of discovery; this is 155 Scylla. There are seven more between No. 300 and No. 500.

Two very interesting planets were discovered in 1932. The first is EA_1 = 1221 Amor, found by M. Delporte at Uccle on March 12. A faint image was subsequently found by Nakamura on a plate taken at Kyoto on February 29; it was then close to opposition, but was *advancing* at the rate of $6\frac{3}{4}$ minutes of time daily, the northward rate being $1\frac{1}{2}°$. It was followed for three months, which made it possible to calculate reliable elements; the following were deduced by Dr. Kahrstedt from the first month's observations (*U.A.I. Circ.*, 365): T 1932 April 4·75422 U.T., ω 25° 15′ 25″·6, Ω 171° 9′ 0″·6, i 12° 10′ 48″·3, ϕ 26° 38′ 23″·7, n 1282″·093, q 1·08734, Period 2·7675 years, Equinox 1932·0. The diameter of Amor is probably only one or two miles, and it will be difficult to observe it except near peri-

helion. *Kleine Planeten* for 1933 gives an ephemeris for the opposition of next October, the magnitude then being estimated as 21. The least distance from the Earth's orbit is 0·10935 units, or just over ten million miles; this was the actual distance from the Earth on 1932 March 22.

A diagram of the orbit was given by Dr. Kahrstedt in *R.I. Circ.*, 594; it is reproduced in *B.A.A.J.*, 1932 May. Dr. V. Guth pointed out in *U.A.I. Circ.*, 365, that the orbits of Eros and Amor approach each other closely; he suggested that the two planets might have had a common origin.

A curious feature about the geocentric motion of Amor is that it can be three times in opposition within a few months: some three months before opposition at perihelion the Earth would overtake it in longitude; it would overtake the Earth at perihelion, and the Earth again overtake it three months later.

Rev. Dr. M. Davidson has already given in *M.N.* for 1932 May a preliminary orbit and diagram of the other interesting planet HA, found by Herr K. Reinmuth at Königstuhl on April 24.

Its magnitude was 12½, and it was retrograding at discovery at the rate of 5 minutes of time daily. Dr. Stracke was the first to deduce an orbit, which has proved to be near the truth. He has revised it, using all the positions available, 28 in number, extending from April 27 to May 15, and applying perturbations by Venus, Earth and Jupiter; he finds the following elements (*Astr. Nach.*, 5919): Epoch and Osculation 1932 April 25·0 U.T., M 319° 59′ 1″·60, ω 284° 51′ 48″·73, Ω 35° 50′ 19″·59, i 6° 25′ 10″·85, ϕ 34° 29′ 18″·94, n 1958″·6005, Equinox 1932·0, a 1·4860743, Period 1·8116 years, q 0·6445963, Aphelion distance 2·3275523, Perihelion passage 1932 July 5·5517 U.T.

The perihelion point is 7½ million miles inside the orbit of Venus, the aphelion point 61 million miles outside that of Mars. There is an approach to the Earth's orbit at two points within about 3 million miles. The approach to the Earth last May was within 6½ million miles, which is much the closest at which a planetary body has ever been observed. The orbit also approaches that of Venus very closely. The planet can transit the Sun at the Ascending Node, being then about 9 million miles inside the Earth's orbit; as it is only about a mile in diameter, it would probably be too small to observe.

The most doubtful element is the period, which may be in error by about a week; this may make the planet's recovery difficult. Great efforts were made to find it from August to October, but these were unsuccessful, the distance from the Earth being too great; there should be a chance of finding it in the spring of 1934, when it is approaching perihelion.

Both Amor and HA had very large parallaxes, owing to their close proximity. This afforded help in deducing their distances from the Earth. In the case of Amor the shift was mainly in R.A.; in the case of HA the shift in declination between Europe and Johannesburg was about 100″.

A. C. D. C.

Comets

Thirteen comets were detected in 1932, which is a record. However, two of the objects were not observed sufficiently to deduce orbits, and another proved to have passed perihelion in 1931; thus there were ten perihelion passages in 1932, the same number as in 1898, and one less than in 1925.

Three comets previously discovered were still under observation early in 1932; 1925 II (Schwassmann-Wachmann) was followed at Bergedorf till February 6, and again observed there on December 26; in February it was of magnitude 14, with a coma 60″ in diameter and a distinct nucleus; in December the magnitude was 17. 1931 I (Neujmin I) was followed at Mount Wilson till January 10; 1931 III (Nagata) was followed at Yerkes till March 10, when its magnitude was 16; apparently its period is longer than the value, 267 years, given in the last Report.

1932 *a* was a very faint object found near the Orion nebula by Professor van Biesbroeck on March 6; it was thought at first to be comet

Table of Elements of Cometary

Ref. No.	Year and Number of Comet	Name	T	ω	Ω	i
				° ′ ″	° ′ ″	° ′ ″
464	1905 IV	Kopff	Oct. 17·75447	158 37 51	342 20 0	4 16 12
493	1911 II	Kiess	June 30·15536	110 19 20	157 24 49	148 25 37
594	1931 I	Neujmin (1)	Apr. 30·1237	346 57 27	347 19 2	15 8 56
598	1931 V	Carrasco	Nov. 30·4698	110 12 35	17 50 53	58 3 53
599	1932 I	Houghton-Ensor	Feb. 29·21	303 45	212 30	74 26
...	1932	Tempel-Swift	P Apr. 4·15	153 46	249 55	10 23
600	1932 II	Grigg-Skjellerup	May 12·59	355 11 56	215 31 16	17 26 40
601	1932 III	Kopff	P Aug. 21·1583	19 44 23	263 56 13	8 42 22
			Obs. 21·4			
602	1932 IV	Borrelly	P Aug. 27·8156	352 33 9	77 3 43	30 31 47
			P Aug. 26·268	352 30 53	77 4 2	30 32 25
			Obs. 27·2			
603	1932 V	Peltier-Whipple	Sept. 1·8510	38 28 0	344 30 54	71 42 54
604	1932 VI	Geddes	Sept. 21·2878	329 47 31	215 9 39	124 59 25
605	1932 VII	Newman	Sept. 24·5593	69 48 20	245 8 23	78 23 1
606	1932 VIII	Brooks	P Oct. 7·623	195 48 47	177 27 7	5 32 48
			P Oct. 7·5519	195 48 18	177 27 11	5 32 52
			Obs. 9·5			
607	1932 IX	Faye	P Dec. 5·875	199 51 43	206 13 30	10 36 8
			Obs. 5·7			
608	1932 X	Dodwell-Forbes	Dec. 30·5285	327 23 4	78 12 22	24 20 30

Notes.—For Nos. 464, 493, T is expressed in old G.M.T.; for the remainder in G.C.T.
P denotes a Predicted Orbit. Obs. denotes T as deduced from observation.

Grigg-Skjellerup, but this was disproved; it may, however, have been an emanation from that comet as its motion was similar. It was not seen again.

1932 *b* (magnitude 9) was found on April 1 by Mr. H. E. Houghton at the Cape; Mr. G. E. Ensor found it at Pretoria a day later, and it bears the double name; both detections were made in the course of study of the variable T Apodis. The comet travelled rapidly northward and was observed in Europe and America till June. It appears to have a period of a few centuries. On April 27 it had a large coma, 8′ in diameter, with a well-defined nucleus (van Biesbroeck).

1932 *c* (magnitude 12) was found photographically at Madrid by R. Carrasco on April 22; it had passed perihelion several months earlier. On April 27 it had a stellar nucleus and a tail 1′ long in P.A. 110° (van Biesbroeck). There is little deviation from a parabola. It was followed till the end of June. Prediscovery images were found on five Harvard plates, the earliest being on April 13.

1932 *d* was the periodic comet Grigg-Skjellerup, this being its fourth observed apparition; it was found by van Biesbroeck on April 28, being of

Orbits, published in 1932.

Ref. No.	log *q*	Period in Years or Eccentricity *e* in Hyperbolic Orbits	Equinox	Computer	Reference
464	0·523677	(*e* = 1·001046)	1910·0	H. Werner	*A.N.*, **247**, 68.
493	9·834800	1903	1911·0	L. Lindsey	*A.J.*, 983.
594	0·184034	17·73739	1931·0	S. B. Nicholson	*A.J.*, 976.
598	0·367003	...	1932·0	F. L. Whipple, L. E. Cunningham	*Harvard C.*, 230.
599	0·0993	545·45	1932·0	— Bobone	*Harvard C.*, 217.
...	0·1225	5·9413	1932·0	A. C. D. Crommelin	*Obs.*, 1932 Jan.
600	9·95787	5·0216	1932·0	,,	MS.
601	0·227430	6·55675	1932·0	F. Kepinski	*Warsaw Instit. Pub.*, No. 7.
602	0·141593	6·87483	1932·0	A. Schaumasse	*U.A.I. Circ.*, 365.
	0·141218	6·87179	1932·0	W. P. Henderson, J. D. McNeile	*B.A.A. Hdbk.*, 1932.
603	0·015875	302·5	1932·0	A. D. Maxwell	*Pub. Univ. Michigan*, 5, 2.
604	0·364116	(*e* = 1·000349)	1932·0	— Bobone	*Harvard C.*, 248.
605	0·216710	...	1932·0	— Schmitt	*U.A.I. Circ.*, 402.
606	0·271798	6·93539	1932·0	F. R. Cripps	*B.A.A. Hdbk.*, 1932.
	0·27183	6·93474	1932·0	A. Dubiago	*A.N.*, **245**, 297.
607	0·208701	7·32133	1932·0	A. C. D. Crommelin	*B.A.A. Hdbk.*, 1932.
608	0·050552	69·8923	1932·0	,,	*Obs.*, 1933 Feb.

magnitude 11. It passed within 22 million miles of the Earth early in June, and was observed till July. Its period is so close to five years that the conditions nearly repeat themselves at successive returns.

1932 *e* (magnitude 12) was the periodic comet Kopff; it was found by Mr. Bobone at Cordoba on May 25. It was followed till the end of the year, moving in close accord with the predicted elements of F. Kepinski.

1932 *f* (magnitude 12) was found by Mr. Newman at the Lowell Observatory; the announcement was made on June 20, but images were found on earlier plates, going back to June 1. These were measured by Dr. Whipple (*Harvard Card* 249). Professor van Biesbroeck was still observing it in December, its magnitude then being 13·5. Its orbit does not differ much from a parabola.

1932 *g* (magnitude 9) was found by Mr. M. Geddes at Otekura, Otago, New Zealand, on June 22; it resembled 1932 *b* in being found in the course of work on variable stars, and in being near the South Pole. It was well observed in New Zealand, Johannesburg, Cordoba and La Plata, and at the end of the year at Yerkes and Tashkent. Mr. Bobone has calculated several successive orbits of this comet, which show a tendency, though not very decided, to hyperbolic motion. This point needs to be tested by continued observation. The comet is now in north declination. The *B.A.A. Handbook* for 1933 contains an ephemeris for the whole year. The perihelion distance is nearly $2\frac{1}{2}$ units.

1932 *h* (magnitude 13) was found by M. Schmitt at Algiers on June 25; it was close to Newman's comet and had a similar motion; it is probable that it was an emanation from that comet. There is some evidence of a second emanation, but both faded rapidly; there is not enough material to deduce independent orbits for them.

1932 *j* (magnitude 12) is the periodic comet Borrelly, which was found by Professor van Biesbroeck at Yerkes on July 30; it was followed up to the end of the year.

1932 *k* (magnitude 8) was found independently by Mr. L. Peltier at Delphos, Ohio, on August 8 (visually), and by Dr. F. L. Whipple at Harvard (photographically), the plate being taken on August 6. Mr. H. T. Sase discovered it independently on August 9 (*Harvard Card* 236). Mr. Peltier has now discovered three comets in the course of his work on variable stars. This was the brightest comet of the year, having a tail 1° long on August 10 and reaching magnitude 6·3 at the end of August, when it was within 10° of the North Pole. It was, however, invisible at Yerkes in December. Several accordant determinations of the orbit were made; the period is about three centuries. *Astr. Nach.* 5905 contains drawings and descriptions of the comet's appearance by R. M. Aller.

1932 *l* (magnitude 12) is the periodic comet Faye; it was detected by Professors Schwassmann, Wachmann and Guyot at Bergedorf on August 30; it was approaching both Earth and Sun, and reached magnitude 11. It is still under observation at Yerkes. On November 20, F. Lause reported a tail 65″ long in P.A. 70° (*B.Z.* 46).

1932 *m* (magnitude 12) is the periodic comet Brooks, found by Professor

van Biesbroeck at Yerkes on September 25. M. Delporte had already photographed it at Uccle on September 8, but did not announce it, as he could not obtain a control plate. The perihelion passage was $1\frac{3}{4}$ days later than the accordant predictions of Mr. Cripps and Professor Dubiago. This is not a large discordance considering that the comet was not seen from 1903 to 1925, except for one doubtful observation in 1910. The comet was followed till the end of the year. *Popular Astronomy* for 1933 January contains an interesting photograph taken by Professor van Biesbroeck on November 28 ; it shows comet Faye (magnitude 11) and Brooks (magnitude 13) only half a degree apart, both had short tails.

1932 *n* (magnitude 9) was found independently by Mr. G. F. Dodwell, Government Astronomer at Adelaide, and by Mr. A. F. I. Forbes at Hermanus, Cape Colony (this being his fourth cometary discovery). Mr. Forbes found it on December 15, but owing to a public holiday transmission was delayed, and the Australian message reached Europe first. It had a round coma 3′ in diameter, but without stellar nucleus or tail. A Yerkes' photograph is reproduced in *Popular Astronomy* for January. The preliminary orbit given below, from a 19-day arc, seems to indicate that the comet is a tenth member of the Neptune family ; its period is near the mean of the family, which is 71 years.

Unsuccessful search was made for five other periodic comets : Schorr, Tempel-Swift, Wolf II, Neujmin II and Tempel 1866 I. The first two and the fourth were carefully looked for at Bergedorf. There is still a possibility of the third and fifth being detected. Search ephemerides are given in *U.A.I. Circ.* 419 and in *B.A.A. Handbook* for 1933 respectively.

A. C. D. C.

Solar Activity

Sunspots.—The Sun's general activity continued to decline during the past year, but the minimum of the 11-year cycle has apparently not yet been reached. The mean daily area of spots, corrected for foreshortening, was about 165 millionths of the Sun's hemisphere as compared with 275 millionths for the previous year. The number of spots decreased in about the same ratio. There were about 90 days on which no spots were visible. Three spot disturbances exceeded 500 millionths in area, (1) a large stream that developed rapidly within a few days from some tiny spots on April 21 to a group 800 millionths in area, (2) a stream of rapid growth between November 16 and 21, when on the latter date its area exceeded 1000 millionths, and (3) a large regular spot (being the return of the leader spot of the previous group) with an area exceeding 500 millionths on several days. The times of central meridian passage and the latitudes of these are as follows :—

Apr. 25·4	10° N.
Nov. 16·2	10° N.
Dec. 13·0	10° N.

Of the smaller groups may be mentioned the leading spot of a stream in latitude 8° S., first seen from July 2 to 12, that lasted for 63 days. A very

small spot was detected on January 14 in high northern latitude (48°) (*Journ. B.A.A.*, **42**, 242, 1932).

The following groups of sunspots, designated by their respective times of central meridian passage and their solar latitudes, were observed to be active spectroscopically at one or more of the following observatories: Greenwich, Mount Wilson, Zurich and Mr. Newbegin's observatory at Worthing.

(1) Jan. 23·5 [− 6°] (2) Feb. 1·4 [+13°] (3) Feb. 27·0 [+ 5°] (4) Mar. 4·4 [+12°]
(5) Apr. 17·0 [− 8°] (6) Apr. 25·4 [+10°] (7) May 13·8 [− 8°] (8) May 22·3 [+10°]
(9) May 26·4 [+ 4°] (10) June 30·7 [+12°] (11) Aug. 2·5 [− 9°] (12) Aug. 25·4 [− 6°]
(13) Oct. 6·9 [+11°] (14) Oct. 24·4 [+10°] (15) Dec. 5·0 [+ 5°] (16) Dec. 13·0 [+10°]

Spots Nos. 1, 3, 4, 6, 9 to 15 were associated with small bright eruptions seen in *Hα*. Spots Nos. 2, 4 to 9, 13 and 16 were associated with dark hydrogen flocculi with measured radial velocities of the order of 50 km./sec. or greater; the largest velocities, of the order of 90 or 100 km./sec., were associated with spots Nos. 6, 9, 13 and 16.

It may be added that the number of magnetic disturbances recorded at Abinger, in which the range in $D \geqslant 30'$ or in H or $V \geqslant 150\gamma$, was 11 as compared with 7 in 1931 and 23 in 1930. The disturbance of 1932 May 29–30 was the largest recorded at Abinger since 1929 March (*The Observatory*, **55**, 177 and 207, 1932).

H. W. N.

Prominences, 1932.—All forms of prominence activity show a considerable decrease below the 1931 figures. Calcium and hydrogen prominence areas show a decrease of 47 per cent. and 38 per cent. respectively, the daily numbers of prominences a decrease of 27 per cent., and the areas of *Hα* dark markings a decrease of 37 per cent.

The mean daily areas of calcium prominences in square minutes of arc, as derived from the Kodaikanal spectroheliograms, are as follows:—

	North	South	Total
1932 January to June	1·35	1·32	2·67 sq. mins.
July to December	0·98	0·77	1·75 ,,

Except for a peak between latitudes 40°–50° in the southern hemisphere in the first half of the year, the prominence activity up to latitudes 50° is fairly uniform; the disappearance of the peak in the second half of the year accounts for the defect of areas in the southern hemisphere. The mean daily numbers of calcium prominences were 10·9 and 8·7 respectively in the first and second halves of the year.

As against 25 prominences exhibiting metallic lines observed during 1931, only 2 were observed during the first half of 1932 and none during the second half. One was at latitude 16°·5 N., and the other at latitude 12°·5 S. Displacements of the hydrogen line in the chromosphere and prominences observed during the year numbered 105, as against 245 in the previous year. Of the displacements 59 were towards the red, 45 towards the violet and 1 both ways simultaneously. Bright reversals of the *Hα* line

in the neighbourhood of sunspots numbered 133, while those observed in the previous year were 300. Displacements of the *Hα* line on the disc totalled 9, as against 37 in 1931. Of these displacements 8 were towards the red and 1 was towards the violet. D_3 was observed as a dark line on 123 occasions, as against 282 during the previous year.

The mean daily areas of prominences projected on the disc as absorption markings in hydrogen light were 1338 millionths of the Sun's visible hemisphere. Their latitude distribution is very similar to that of prominences at the limb, except that in the southern hemisphere the activity in the second half of the year is practically confined to the belt 40°–50°, which is not the case for prominences at the limb.

The mean daily areas of hydrogen prominences in square minutes of arc are as follows :—

	North	South	Total
1932 January to June	0·49	0·52	1·01 sq. mins.
July to December	0·36	0·26	0·62 ,,

The distribution in latitude is generally similar to that of calcium prominences.

T. R.

Solar Research

One of the primary objects of recent solar research has been the study of matter which is traversed by a flux of high temperature radiation and is in gravitational and rotational equilibrium. Such research leads not only to a more profound knowledge of the physics of this interaction of matter and radiation, but also to a deeper insight into the nature of stellar atmospheres. Interest in solar physics, which had somewhat lapsed during a period coincident with the construction and early use of large reflectors, has now to a large extent been restored to its early place in astrophysics, and each succeeding year is characterized by an increasing number of significant papers. The year 1932 has been no exception to this rule, and in the present note it will be possible only to describe a few of the papers which have appeared.

Corona.—Mitchell (*Ap. J.*, 75, 1) discusses the spectrum and the shape of the corona as observed by him at the 1930 eclipse. He records the discovery with an objective grating spectroscope (11 A. per mm.) of a new coronal line at λ 6776 ; he gives the results of careful determinations of the wave-lengths of λλ 5303, 6374 and 6776, and fully discusses the behaviour of the nineteen lines of unknown origin peculiar to the corona. He concludes from a study of this and previous eclipses that the only possible grouping of lines of similar behaviour is that of λλ 3601, 4086, and that of λλ 3388, 5303. In this connection he draws attention to the differences in the prominence-like structure shown by the slitless images of λ 5303 and of λ 6374, a result confirmed for the 1932 eclipse by Davidson and Jackson (*M.N.*, **93**, 3) and by Menzel (*Pub. A.S.P.*, **44**, 358). Mitchell determines the shape of the corona by Ludendorff's isophote method, and shows that

there is a similarity in period but a difference in phase of solar activity and coronal shape as measured by Ludendorff's coefficient *b*. From microphotometer measures of the 1926 corona, von Klüber (*Z.f.Ap.*, 4, 1) makes a quantitative test of Ludendorff's method of finding isophotes, and obtains excellent agreement. In connection with the photography of the corona attention should be called to Wright's decision (*Pub. A.S.P.*, 44, 352) to abandon the 40-foot Lick camera, and substitute for it a camera with a lens of the same aperture but of only 15 feet focal length. This shorter focal length instrument not only has the same resolving power, but is simpler to mount and has something like five times the speed.

It is now over forty years since the first of many distinguished investigators unsuccessfully attempted to detect the corona without an eclipse. To Lyot is due the credit for the first success in this technically highly difficult task—a success due far more to his ingenuity than to the expense or the complexity of his apparatus. In a recent paper (*Z.f.Ap.*, 5, 73) he discusses the methods used and the results obtained by him during the summer of 1931 on the Pic du Midi. His principal piece of apparatus is a coronagraph, ingeniously arranged to reduce instrumental scattering to a minimum, and with this, choosing times when the intensity of scattered sky light is less than five-millionths that of the Sun, he has succeeded for the first time in directly photographing the inner corona without an eclipse. The photographs have been made with the continuous spectrum of the corona in the region λλ 6600–6800. By coupling this coronograph with a spectroscope which, used with a concave grating, gives a dispersion of 1·2 A. per mm., or with a Littrow prism arrangement gives 5 A. per mm. at λ 5300, he has succeeded in photographing the coronal line λ 5303 at various points about the disc of the Sun, and has determined the wave-length of this line and also of λ 6375 with an accuracy far greater than that hitherto obtained. He comments on the great width of λ 5303, a result recently confirmed by Shane at the 1932 eclipse (*Pub. A.S.P.*, 44, 360), and for the first time he seems definitely to have found a rotational displacement of the inner corona, amounting to some 2 km. per second.

Lyot's work, which even thus early has given new and significant results, makes it highly desirable that eclipse problems be to some extent standardized. It is to be hoped that advantage may be taken of the Paris meeting of the I.A.U. to reach some decision, in the light of Lyot's work, as to what problems can be adequately attacked only during eclipses, and further which of these, in the light of our present knowledge, justify the large expenditures in time, effort and money which the average eclipse expedition entails.

Prominences.—Pettit continues his valuable work on the prominences (*Ap. J.*, 76, 9). He rediscusses old material and brings forward new material which seem conclusively to show that the motion of eruptive prominences is uniform, but with occasional abrupt changes in velocity. Especially conclusive are the independent measures by four skilled observers of a particular eruptive prominence. Pettit finds difficulty in attributing such motion to the effects of radiation pressure; he is confirmed in this

difficulty by the fact that hydrogen and ionized calcium show an exactly similar distribution in all types of prominences, whereas if radiation pressure were effective a separation of elements might possibly be expected. In this connection it is worth noting that Menzel (*Pub. L.O.*, **17**, 295) concludes from stationary plate spectrograms of the 1905 eclipse that there is no evidence for the separation of hydrogen, helium, ionized helium, ionized calcium, strontium and titanium in prominences.

Chromosphere.—Keenan (*Ap. J.*, **75**, 277; **76**, 134) photometrically studies the contours of the chromospheric hydrogen lines from flash spectra made without an eclipse. The large aperture ratio of the Yerkes telescope makes it a highly efficient light collector, and with the Rumford spectroheliograph, used as an ordinary spectroscope with a dispersion of 3·5 A. per mm., Keenan is able to get satisfactory flash spectra with exposures of less than fifteen seconds. His spectra are standardized with a tube sensitometer, and contours are obtained in the usual way from microphotometer tracings. These contours, after correction for the superposed continuous spectrum produced by atmospheric scattering and unsteadiness of the solar image, are then compared with the contours first theoretically predicted by Unsöld for such chromospheric lines. If the scattering coefficient arises from radiation damping, these lines should all be doublets with zero intensity between the components. Actually, after the correction is applied for the superposed continuous spectrum, there remains little or no evidence for doubling, and though Keenan is able to account for the shape of the lines by assuming a velocity of turbulence in the chromosphere of 15 km. per second, it may perhaps be questioned whether Unsöld's theory is applicable to the hydrogen lines. The observation by Davidson and Stratton of a strong Balmer continuous spectrum in the chromosphere, and the recent observation by H. W. Babcock (*Pub. A.S.P.*, **44**, 323) of the lines of the Paschen series in emission to the sixteenth member, in a flash spectrum without an eclipse, make it probable that the Balmer lines are formed by recombination, not by resonance scattering.

In what seems likely to prove, for some years to come, the standard investigation on the chromosphere, Menzel (*Pub. L.O.*, **17**, 1) gives the results of his studies of the Lick Observatory flash spectra, made with the moving-plate camera at the eclipses of 1905 and 1908. The basic contribution of the paper is contained in Table I, where the wave-lengths, estimated intensities, heights, line class, predominant origin and multiplet of each flash spectrum line is given. In Table II are given measured line intensities from microphotometer tracings made at different "levels" in the spectrum. Since the importance of plate standardization had not been generally realized at the time when these plates were taken, Menzel has been forced to assume a characteristic curve for the unknown emulsion on which the spectra were made. The resulting intensities, as he fully realizes, can only be regarded as rough first approximations; indeed the fact that his line widths, photometrically determined, increase with chromospheric height, in direct contradiction to the accurate photometric work of Unsöld and Keenan, is

probably to be traced to the absence of standardization on his plates. Tables III and IV of his paper are summary tables arranged in order of element and multiplet rather than wave-length.

In a stimulating discussion of this observational material Menzel reaches interesting results on the density gradient, abundance of elements, and the nature of the equilibrium in the chromosphere. To determine the density gradient he first derives the integral equation connecting the intensity of the unreversed chromospheric line at height r, as observed with a moving-plate camera, and the unknown density function ; from an analytical representation of his mean observed intensities, empirically corrected for self-reversal, as a function of height, he solves this integral equation to find the unknown density function. The density gradient turns out to be the same as would be shown by an atmosphere of atomic weight unity at a temperature of 5000° in gravitational equilibrium. In view of the very different behaviour of intensity as a function of height shown by neutral calcium, ionized strontium, neutral helium and the ionized rare earths, it is difficult to know the meaning which is to be attached to this averaged density gradient. Menzel's preliminary survey shows, however, the kind of information which may be derived from standardized moving-plate flash spectra, and provided the very serious difficulties involved in correcting for self-reversal can be overcome (for example hydrogen lines, if formed by recombination, and ionized calcium lines, if formed by excitation, will have to be treated differently), we may hope for accurate density gradients for the various elements. Russell's method has been used to determine the relative abundance of elements in the chromosphere, and for the chromosphere Menzel's results are very similar to those obtained by Russell for the absorption spectrum. The question of the equilibrium of the chromosphere is of course closely connected with the observed density gradient ; from the density gradient found by himself, Menzel concludes that the rôle of radiation pressure is not to produce the static equilibrium of Milne's theory, but rather to produce turbulence in the chromosphere.

Absorption Lines.—The year has been characterized by a number of interesting theoretical papers on the formation of absorption lines. ten Bruggencate (*Z.f.Ap.*, 4, 159) develops a method whereby the ratio of the macroscopic scattering to absorption coefficient in the absorption line can be determined as a function of optical depth, from a knowledge of the variation of these coefficients as a function of frequency across the line, and from the observational determination of many contours across the disc. This method yields the required variation with optical depth by dividing the atmosphere into a finite number of levels, within each of which the coefficients are assumed to be constant. Following ten Bruggencate's work, Unsöld (*Z.f.Ap.*, 4, 339) throws the differential equation of transfer for absorption and scattering into Schwarzschild's integral equation, and derives an approximate solution of this equation for continuous variation with optical depth of the coefficients of absorption and scattering. His approximate solution, which is valid only for the line wings, he then tests

on the cases treated by the Schwarzschild, Schuster and Eddington models, and finds satisfactory agreement within the observable limits of cos θ.

If the variation of scattering and absorption coefficients across the line is that given by radiation damping, the sum of these coefficients will be infinitely large at the line centre, and Pannekoek has shown that in an atmosphere where de-excitation by collisions of the second kind decreases to zero at great heights, the line centre will be perfectly black. Since observationally the lines have a considerable residual intensity at the centre, Unsöld (*Z.f.Ap.*, 4, 319) has attempted to remove this difficulty of the radiation-damping theory, by considering that atoms in the upper of the two states under consideration may be removed from this state, not only by spontaneous re-emission and collisions of the second kind, but also by being lifted to still higher states by absorption of radiation. This may be considered to have a dual effect: it not only renders the atoms less efficient as absorbers (they work much less frequently), but also it increases the probability of a collision of the second kind, for the atom remains a much longer time in an excited condition. Unsöld makes a numerical estimate of the residual intensity from an application of the Eddington model (now strictly applicable), using probable values of the transition coefficients, and finds residual intensities comparable with those observed. The same problem has also been treated by Woolley (*Z.f.Ap.*, 5, 67) by a different method. He shows that an appropriate assumption as to the variation of the absorption and scattering coefficients with optical depths leads to absorption lines with residual central intensities other than zero.

An important paper on the observational determination of line contours has been published by Shane (*L.O.B.*, **16**, No. 449). A well-known integral equation connects the observed contour with the true (and unknown) contour and the pattern given by the spectroscope for a monochromatic line, the latter appearing as the kernel of the integral equation. This equation can be transformed so that a detailed knowledge of the kernel is required only for values near the line itself, and outside these limits the integral can be treated as a constant, generally known as the "scattered light." This latter arises from general scattered light in the spectroscope, linear scattering in the direction of dispersion (a characteristic of gratings), Rowland ghosts and scattering in the emulsion. An accurate determination of line contour therefore resolves itself into a choice of an instrument giving a concentrated and accurately known kernel, and an exact determination of the "scattered light." Following a method first extensively used for absorption spectra by Burns, Shane crosses a grating spectroscope with a Fabry and Perot *étalon*. If the spectroscope be used with a narrow slit this produces what Burns calls a channelled spectrum. At each wave-length is a diametral section of the interference pattern, and for a given order of interference the fringes form parabolas. A fringe may now be found which crosses the absorption line to be measured, and, by measuring its intensity microphotometrically on standardized plates at different points on the line, an observed contour may be obtained. As is well known, the kernel of the integral equation for a Fabry and Perot interferometer is highly concentrated, the

more so the greater the reflectivity of the plates, and its analytical form is accurately given by theory. The "scattered light" for the Littrow spectroscope of the Snow Telescope of Mount Wilson, with which the spectra were made, is found by Shane by a number of ingenious methods, and after a solution of the integral equation by successive approximations, he derives true contours for six lines at λ 5500 with Rowland intensities one to eight. The paper is a mine of suggestive ideas, and sets a new standard in the observational determination of line contours.

Continuous Spectrum.—Pettit (*Ap. J.*, 75, 185) gives details of his method of measuring the ratio of solar radiation intensity at λ 3200 to that at λ 5100. The method is automatic and very direct; it seems open to no obvious criticism, but it results in the apparently incredible variation of 60 per cent. in the ultra-violet light emitted by the Sun. Observations have been made since 1925, and the resulting variation of ultra-violet radiation shows a fair correlation with the number of sunspot groups. The paper concludes with a new determination of the spectral energy curve of the Sun in the region λλ 3000–6000. A double monochromator was used, the second slit being arranged so as always to include 100 A., and the energy was measured either with a thermocouple or with a sodium photo-electric cell, whose colour sensitivity had been independently determined.

Sunspots.—Miss Moore (*Ap. J.*, 75, 222, 298) gives a valuable and detailed study of the sunspot spectrum, using for this purpose the Mount Wilson map. From this map Rowland intensities and nearly complete identifications have been assigned to over 6000 lines occurring in sunspots. Though this extended table is not published in the present paper, measures and identifications are given in her paper of some 470 atomic lines occurring only in sunspots. A by-product of her work has been an extension of identifications of lines in the ordinary solar spectrum, and a list is published of over 900 lines, which have been recognized as members of multiplets so faint that they have not yet been found in the laboratory. Miss Moore then applies the Russell-Adams calibration method to this material and derives a temperature of 4720° for the spot, and a pressure six-tenths of that observed on the disc. In view of the many factors involved in the formation of absorption lines, in addition to the number of atoms in the lower of the two states, these results may perhaps be described as stating that the spectra shown by spots can be qualitatively accounted for by the assumption of an otherwise not unreasonable temperature and pressure.

Minnaert and Wanders (*Z.f.Ap.*, 5, 297) discuss the temperature gradients in sunspots from the corrected observations of Pettit and Nicholson of energy distribution, and from what little is known of contrast towards the limb shown by the spots. They reach the exceedingly interesting conclusion, after exploring a number of other possibilities, that the temperature gradient corresponds to that for radiative equilibrium, and hence that the convective processes must take place well below the level to which we can see. This

result, if confirmed by their own promised and very badly needed observations of the limb contrast in spots, is extremely important and very surprising.

H. H. P.

Stellar Spectroscopy

Spectrophotometry.—Several improvements in exisitng forms of registering spectrophotometers, and suggestions for new methods or simplified forms of apparatus, have been made during the year ; the more important of these being described below. Practical applications of such instruments (apart from their use in investigations recorded elsewhere) have not been numerous, and three of those to be mentioned in this section refer to studies of *H* line contours.

The use of a radiometer as the light-sensitive element has been tried at the Mount Wilson Observatory with some success (1). Such an appliance gives certain advantages over photo-electric cells or thermocouples, particularly in being highly sensitive as well as easily and rapidly operated. The radiometer was specially designed for this type of work, the object being to gain speed as much as possible by damping down the oscillation period without undue loss of sensitivity. The design of the whole apparatus was made as simple as possible, and should be comparatively easy to construct. The method of amplifying the current by means of thermionic valves, in those instruments which employ photo-electric cells, has been several times suggested. It is now in use at the Victoria Observatory in a new type of direct-reading instrument recently described by Beals (2). Such an instrument is in some ways more convenient and easily worked than one of the self-registering type, while its high resolving power and sensitivity make it very suitable for measuring narrow lines such as those of interstellar calcium.

An investigation on *H* lines in stellar spectra has been made by E. M. Lindsay (3), who used unstandardised spectra calibrated by means of multiplets in the *Fe* comparison spectra, in the manner suggested by Hogg. Unsöld's theoretical curves could not be made to represent satisfactorily the observed contours ; so, following Shajn and Struve, an exponential curve was adopted which fitted the observations more accurately. The formula used was

$$I = I_0 e^{-k(\lambda - \lambda_0)^p},$$

where I and λ are the intensity and wave-length at any point, the suffix o representing central values. The quantities I_0, k and p vary throughout the stellar sequence as well as for different members of the Balmer series ; p reaching a minimum (1·0) at type *A*, and maxima (2·0) for early and late types. The correlation between total *H* absorption and absolute magnitude is confirmed as far as the scanty material allows. This correlation has also been investigated by Öhman (4) in the case of Pleiades stars measured at Stockholm Observatory with a Schilt photometer. His earlier conclusions that the *H* lines form a sensitive criterion of luminosity for high-temperature

stars is confirmed. E. G. Williams (4*a*) has examined the variation in *H* absorption lines with effective temperature and surface gravity (determined from the mass-luminosity relation). He finds that an exponential curve fits most of the contours for early type stars. The total absorption reaches a maximum between 10500° and 12500° (types A5 to A0); it also decreases with increasing luminosity above 7500°, though this absolute magnitude effect is only slight, or of opposite sign, at lower temperatures.

Greaves, Davidson and Martin (4*b*) have published the results of a prolonged study of colour temperatures. The difficulty of obtaining absolute values by direct comparison with a terrestrial source was surmounted by first selecting 25 standard stars. These were elaborately intercompared to obtain the relative gradients, from which absolute values of colour temperatures were derived by comparison with a specially designed acetylene flame. Colour temperatures for all other stars were then obtained simply by comparison with one or more standard stars. Results are given of the absolute colour temperatures of 63 stars (including the 25 standards).

Bright-Line Stars.—There has been considerable activity in the study of bright-line stars, principally those of type B. The results are concerned with the discovery of hitherto unrecorded bright-line spectra (mainly of comparatively faint stars) and with theories of the origin of the emission lines, as well as detailed systematic studies of individual Be-type stars, the majority of which have proved to exhibit spectral variations.

Merrill, Humason and Burwell (5) have published a list of 138 newly discovered bright-line stars, which brings the number of such objects discovered at Mount Wilson up to 233. The authors give the intensities of all the *H* emission lines, and find that these reach a maximum in stars of types B0 to B3. A spectroscopic survey of 45 of the brighter Be stars has been made by McLaughlin (6) from spectra obtained at Michigan. This comprises the majority of such stars brighter than magnitude 6·0 in declinations North of −20°, and includes brief descriptions of the outstanding features of each star. The three bright stars, κ Cas., o Cas. and H.D. 24479, have recently been discovered by Wilson (7) to possess bright lines. The last is of special interest owing to the fact of its comparatively late spectral type (B9).

Struve and Swings (8) have discussed the interpretation of emission lines in Be stars, and in spite of some possible objections are in favour of the former's theory of origin in a rotating shell of gas surrounding the star; variations in line widths being mainly an effect of inclination of the axis of rotation. This theory receives some additional support from an examination by Struve (9) of the absorption borders on the edges of the bright *H* lines. The contours of these are almost identical with the contours of the same lines in normal stars of corresponding spectral type, which is a necessary condition required by the theory. A somewhat similar theory has been suggested by Merrill (10) in the case of XX Ophiuchi, which contains numerous variable emission lines of *H* and *FeII*. Some analogies to the spectra of novæ suggest to the author a tentative explanation based on a

modified form of Halm's hypothesis of an expanding shell surrounding the star.

The spectrum of B.D. + 10° 4673 has been the subject of a special study by Merrill (11). This is a very peculiar Be star with more than 160 bright lines of various elements, most of which are variable both in intensity and position. Observations during the period 1929–1931 have shown a repetition of the 800-day fluctuations previously described (*Ap. J.*, 69, 330, 1929) without any noteworthy changes.

Amongst other descriptions of individual Be stars may be mentioned: a paper by Miss Losh (12) on 28 Cygni which gives a main variation period of 226 days, with shorter periods of 45·33 and 1·51775 days superimposed; some posthumous notes by R. H. Curtiss (13) on H.D. 20336, 25 Orionis and κ Draconis; and a note on κ Draconis by Jessup (14).

Radial Velocities.—Several publications of considerable importance in radial velocity work have appeared during the year, in the form both of general catalogues of previously published values and of the results of recent observational work. In the former category may be mentioned the catalogue by Plaskett and Pearce (15) of the velocities of early type stars. This contains practically all known values for stars of types O to B5, and includes velocities obtained from interstellar calcium lines when available. Moore (16) has published a general catalogue of radial velocities of stars of all types, which gives all results published prior to 1932 January 1. This includes the velocities of 241 nebulæ and clusters, as well as the main catalogue of 6739 stars. In addition to individual values a weighted mean is given for the majority of stars in each of these two catalogues.

The results of six years' work at Victoria on O- and B-type stars has recently been published by Plaskett and Pearce (17). The observations were restricted to stars of types O to B5 brighter than magnitude 7·5 in declinations north of −11°. The results for 523 such stars are given, and in addition a list of 117 new spectroscopic binaries discovered during the course of this work. These radial velocities are included in both of the above-mentioned catalogues.

Shajn and Albitzky (18) have published the velocities of 301 stars obtained from spectrograms taken at the Simeis branch of the Pulkovo Observatory with the new 40-inch reflector. Systematic corrections deduced from a further list of 42 standard stars are small, being only −0·5 km./sec. for types G to M and −0·1 km./sec. for types B8 to F8. The main list contains stars of magnitudes 5·75 to 6·50 mostly unobserved previously. Amongst these, 30 new spectroscopic binaries were detected.

Spectroscopic Parallaxes.—A considerable number of spectroscopic parallaxes and absolute magnitudes have been published during the year, mainly from Harvard and Upsala Observatories. They refer mainly to restricted areas of the sky, and include stars of fainter apparent magnitudes than have hitherto been treated by such methods. At Harvard special attention has been given to the use of *H* and *He* line intensities in B-type

stars, a further paper on which has been published by Miss Payne and others (19). The authors find that the *H* lines weaken with increasing luminosity, and also suggest that they form the best working criterion of spectral type. The *He* line intensities increase with increasing luminosity above their maximum (at about B2) and decrease below it. They are used to determine absolute magnitudes. Hydrogen lines have been used by Miss Anger (20) to obtain spectroscopic parallaxes of B-type stars in the Perseus cluster and in some of Kapteyn's regions. She has also published (21) spectroscopic parallaxes of 239 early type stars in the neighbourhood of η Carinæ, by the same method.

At Upsala the method used is that developed by Lindblad and Schalén for small dispersion spectra. It has been employed by Schalén (28) and by Stenquist (29) in the course of statistical investigations on certain special areas, and results are given for a considerable number of faint stars.

Several different methods of determining line intensities for this class of work have been used at different observatories—such as optical wedges, and graded scales of artificial comparison lines. A new method of making artificial lines for this purpose has been described by Öpik and Olmsted (22). A drawing of a line is first made by ruling fine lines of definite width and spacing on white paper, the proportion of ink-covered area at any distance from the centre line being under control. This drawing is photographed with a short-focus camera to smooth out the grid-like appearance. The intensity at any point is proportional to the area of ink at the corresponding point in the original drawing, and any desired line contour may thus be imitated.

Amongst theoretical work on this subject may be mentioned a reduction of spectroscopic absolute magnitudes to a uniform system by van Rhijn (23). His system is based on trigonometric parallaxes and mean parallaxes of stars of given proper motion and apparent magnitude. In a discussion of the frequency laws he finds that the spectroscopic absolute magnitudes of stars of a given true absolute magnitude are distributed according to a Gaussian law with only small discrepancies.

Interstellar Absorption.—The detection of interstellar calcium in stars of spectra later than B5 presents considerable difficulties owing to the breadth and intensity of the stellar lines. The conditions necessary to render such observations practicable are that the distance should be at least 10,000 parsecs (in order to give strong absorption) and that the radial velocity should be large enough to give a good separation of the two K lines. These conditions obtain in the binary star H.D. 698 (mag. 7·08, type B9), and Pearce (24) has succeeded in observing the interstellar K line in this system. It is the first case in which such absorption has been definitely established in a star of this type, and affords interesting corroboration of Eddington's theory of diffuse matter in interstellar space.

The explanation of the colour excess in B-type stars continues to receive attention, and evidence is accumulating in support of the theory that it is due, at least in part, to scattering of light by interstellar matter. The

evidence in the case of bright B-type stars has been reviewed by E. T. R. Williams (25); it is favourable to the space-reddening theory, though indicating a somewhat smaller absorption coefficient than that found by Trumpler. Elvey and Mehlin (26) discuss the photo-electric colours of 49 stars in Cepheus, and attribute the colour excesses in this region to the effect of local obscuring clouds. The absence of a correlation with interstellar K line intensities indicates that the light-scattering material is not co-existent with the interstellar calcium atoms.

Miscellaneous.—The determination of spectral types of faint stars has been carried out at several observatories. Part of the work of classifying stars in Kapteyn's Selected Areas was undertaken by Mount Wilson Observatory, and Humason (27) has published a list covering the first 115 of these areas. This gives spectral types of 4066 stars down to magnitude 15 (photographic) determined with a slitless spectrograph attached to the 60-inch reflector. The statistical work previously mentioned of Schalén (28) and Stenquist (29) includes the determination of spectral types, the former giving classifications of 3700 stars of types F–M, and the latter 1139 A-type stars.

The spectra of several individual stars have been studied in detail. Morgan and Farnsworth (30) have investigated ϵ Serpentis, which is regarded as a typical example of the A2 dwarfs. Wave-lengths and identifications are given for 244 lines within the range 3997–4629 A. In contrast to some of the Ap stars there is little evidence for the presence of any of the rare earths in this star.

A new type of variation in stellar spectra has been investigated by Struve (31) in the case of 17 Leporis. This star gives a composite spectrum, one part of which (consisting of diffuse *H* and *MgII* lines) shows a zero radial velocity; the second part (consisting of sharp lines of metallic origin) shows large variations in radial velocity with an average value of about – 40 km./sec. The author suggests that the second spectrum might originate in an expanding outer shell of gas. A rather similar type of spectrum is given by 14 Comæ, except that all the lines give the same radial velocity, and Morgan (32) has suggested a similar explanation of its origin. The outer shell in this case, however, would have to be stationary with respect to the central core. Morgan (33) has also investigated intensity changes of the absorption lines *HeI*, 4471, and *MgII*, 4481, in μ Sagittarii. These changes are ascribed to the close approach of the two components at periastron.

A systematic study of A-type stars has been made by Morgan (34) with a view to the detection of Eu^+ in their spectra. The presence of this element has previously been discovered in several peculiar A-type stars, and King's recent list of accurate wave-lengths has enabled Morgan to add 13 stars to the list of those in which it is definitely established, as well as 17 others in which it is strongly suspected. These are all low-temperature stars of types A0–A3. D. L. E.

References

Spectrophotometry

(1) S. Smith and O. C. Wilson, jun., " An Application of the Radiometer: A Registering Microphotometer," *Ap. J.*, **76**, 117.
(2) C. S. Beals, " A Photo-electric Microphotometer using Valve Amplification," *M.N.*, **92**, 196.
(3) E. M. Lindsay, " An Investigation of Hydrogen Lines in Stellar Spectra," *H.C.*, 368.
(4) Y. Öhman, " Note on the Intensities of the Hydrogen Lines of Stars in the Pleiades," *Stock. Obs. Med.*, No. 8.
(4*a*) E. G. Williams, " Stellar Hydrogen Line Contours and their Variation with Temperature and Surface Gravity," *Ann. S.P.O. Camb.*, **2**, pt. II.
(4*b*) Royal Observatory, Greenwich, " Observations of Colour Temperatures of Stars, 1926–1932."

Bright-Line Stars

(5) P. W. Merrill, M. L. Humason, C. Burwell, " Discovery and Observations of Stars of Class Be (Second Paper)," *Ap. J.*, **76**, 156.
(6) D. B. McLaughlin, " A Spectroscopic Survey of the Brighter Be Stars," *Pub. Mich. Obs.*, IV, No. 12.
(7) O. C. Wilson, jun., " Three New Be Stars," *Pub. A.S.P.*, **44**, 124.
(8) O. Struve and P. Swings, " On the Interpretation of the Emission Lines in Stars of Early Spectral Class," *Ap. J.*, **75**, 161.
(9) O. Struve, " On the Absorption Lines of Hydrogen in Be Stars," *Ap. J.*, **76**, 309.
(10) P. W. Merrill, " Spectrum of the Iron Star XX Ophiuchi," *Ap. J.*, **75**, 133.
(11) P. W. Merrill, " The Spectrum of B.D. + 10° 4673 during the Years 1929–31," *Ap. J.*, **75**, 413.
(12) H. M. Losh, " The Spectrum of b^2 28 Cygni," *Pub. Mich. Obs.*, IV, No. 14.
(13) R. H. Curtiss, " Variations of Emission Lines in Three Be Spectra," *Pub. Mich. Obs.*, IV, No. 12.
(14) M. K. Jessup, " Note on the Hydrogen Emission of κ Draconis," *Ap. J.*, **76**, 75.

Radial Velocities

(15) J. S. Plaskett and J. A. Pearce, " A Catalogue of the Radial Velocities of O- and B-type Stars," *Pub. D.A.O.*, V, No. 2.
(16) J. H. Moore, " A General Catalogue of the Radial Velocities of Stars, Nebulæ and Clusters," *Pub. Lick Obs.*, **18**.
(17) J. S. Plaskett and J. A. Pearce, " The Radial Velocities of 523 O- and B-type Stars," *Pub. D.A.O.*, V, No. 1.
(18) G. Shajn and V. Albitzky, " The Radial Velocities of 343 Stars," *M.N.*, **92**, 771.

Spectroscopic Parallaxes

(19) C. H. Payne and others, " Notes on the Scorpio-Centaurus Cluster III—Line Intensities and the Spectral Classification of B Stars," *H.C.*, 365.
(20) C. J. Anger, " Spectroscopic Parallaxes of Early Type Stars in Moving Clusters, *H.C.*, 372.
(21) C. J. Anger, " A Space Survey in the Carina Region," *H.C.*, 373.
(22) E. Öpik and M. Olmsted, " The Construction and Use of a Scale of Artificial Spectral Lines, with application to Absolute Magnitudes of Early Type Stars," *H.C.*, 369.
(23) P. J. van Rhijn, " Reduction of Spectroscopic Absolute Magnitudes to a Uniform System," *M.N.*, **92**, 744.

Interstellar Absorption

(24) J. A. Pearce, " The Co-existence of Stellar and Interstellar Calcium Lines in the Massive Star H.D. 698," *M.N.*, **92**, 877.
(25) E. T. R. Williams, " Evidence for Space Reddening from Bright B Stars," *Ap. J.*, **75**, 386.
(26) C. T. Elvey and T. G. Mehlin, " Photo-electric Colours of Stars of Early Type in Cepheus," *Ap. J.*, **75**, 354.

Miscellaneous

(27) M. L. Humason, " Spectral Types of Faint Stars in Kapteyn's Selected Areas, 1–115," *Ap. J.*, **76**, 224.
(28) C. Schalén, " The Distribution of Stars in Galactic Regions . . .," *Upsala Med.*, No. 55.
(29) E. Stenquist, " A Determination of Spectral Types, Magnitudes and Star Densities in a Region of Galactic Latitude −25°," *Upsala Med.*, No. 54.
(30) W. W. Morgan and G. Farnsworth, " The Spectrum of the A2 Dwarf ϵ Serpentis," *Ap. J.*, **76**, 299.
(31) O. Struve, "17 Leporis : A New Type of Spectrum Variable," *Ap. J.*, **76**, 85.
(32) W. W. Morgan, " A Study of the Composite Spectrum of the A-type Star 14 Comæ," *Ap. J.*, **76**, 144.
(33) W. W. Morgan, " On the Variable Lines of Helium and Magnesium in the Spectrum of 13 μ Sagittarii," *Ap. J.*, **75**, 407.
(34) W. W. Morgan, " Studies in Peculiar Spectra : III. On the Occurrence of Europium in A-type Stars," *Ap. J.*, **75**, 46.

Variable Stars, 1931–32

The large number of papers published during the past two years testifies to the continued popularity of this branch of astronomy. Owing to the simple equipment required, very many workers are occupied in the observation of light variations by the Argelander or other similar methods, and a correspondingly large number of light curves of all classes of variables are being published. Eye estimates on photographic plates also form the basis for a great many light curves, while photographic surveys are leading to a continuous flood of announcements of new variables.

Highly useful as these methods can be, it is beginning to be realized that they are at present less likely to increase our understanding of the physical phenomena presented by the variables than are intensive observational studies of a comparatively small number of stars, carried out with the greatest accuracy modern methods can give, and followed by appropriate theoretical investigation. The past two years have produced a few papers tending to be of this more specialized nature, and although the result appears to be rather more destructive than constructive of current theory, there is no doubt that in the long run such investigations will prove of the highest importance, and should be given the greatest encouragement.

Observational Methods.—A paper of considerable interest to those working by direct visual methods has been given by Minnaert and van der

Bilt,* who were led by systematic differences in estimates of brightness of red variables to investigate the colour vision of two particular observers, and thence the general question of colour sensitivity of the eye as used in this kind of work. It was found that not only are there intrinsic differences of colour sensitivity, but that variations in the use of the "rods" and "cones" of the retina of the eye may lead to systematic colour differences between individual observers. The authors recommend that every observer of red stars should have his eyes tested for colour sensitivity. They point out that in connection with this problem there is a need for determination of energy distribution in the visible region of spectra of M8 – S variables.

The measurement of a star's light by the aid of a photo-electric cell is by no means new, although the advent of the "talkies" has indirectly led to a considerable heightening of interest in the method. A new photo-electric outfit has been attached to the 40-inch refractor at the Yerkes Observatory.† The cell, a Lindemann electrometer and dry batteries are all contained in one unit, which may be readily attached to or detached from the telescope. Arrangement is made whereby air around the photo-electric cell and also inside the electrometer is kept dry, and there is provision for filters and an occulting shutter which may be placed in the optical train. The working limit is at the ninth magnitude, while stars of magnitude 8·0 can be measured easily. The importance of a good photo-electric cell is emphasised, and it is pointed out that most commercial types (which are designed for other purposes) are unsuitable for stellar work. At the Washburn Observatory ‡ a thermionic amplifier with galvanometer has been used successfully with a photo-electric cell. Success has only come after some years of experiment, and is due largely to the FP – 54 Pliotron, a new tube developed specially for this purpose by Metcalf and Thomson at the G.E.C. Research Laboratory. Initially the galvanometer readings were very unsteady, but the disturbances were very much reduced by enclosing cell and amplifier in an evacuated case. The working limit on the Washburn 15-inch refractor is about $9^{m}\cdot0$, against $7^{m}\cdot5$ with the Lindemann electrometer. By reducing the sensitivity of the apparatus, very high accuracy may be obtained on bright stars. A run on ϵ Lyræ gave the probable error of a single deflection as $\pm\ 0^{m}\cdot003$.

Smith § discusses the limiting sensitivity attainable with a photo-electric photometer in stellar work, assuming that difficulties with imperfect insulation, stray leaks, etc., have been overcome. The fainter the light source, the fewer the electrons emitted by the cell per second and the more irregular the emission becomes. This irregularity, which is the ultimate limiting factor, can be smoothed out by waiting, but since in practice one cannot wait for more than one or two minutes, there are clearly limits to the method. It is computed that with the 60-inch reflector it would be difficult to collect data accurate to 1 per cent. on objects fainter than 15^{m}. This paper acquires additional significance in the light of work recently published by Locher

* M. G. J. Minnaert and van der Bilt, *M.N.*, **92**, 422.
† Stebbins, *Ap. J.*, **74**, 289.
‡ Whitford, *Ap. J.*, **76**, 213.
§ Sinclair Smith, *Ap. J.*, **76**, 286.

(*Phys. Rev.*, **42**, 525), who has developed a photo-electric quantum counter consisting essentially of a photo-electric cell and a Geiger-Müller tube counter combined. With this arrangement it becomes possible to detect a "current" of 0·05 electron per second. The only limitations to the sensitivity appear to lie in the amount of dark current given by the photo-electric surface and the time available for counting the emitted electrons. The construction of the instrument is relatively simple.

Bernheimer * has obtained promising results with a new type of selenium cell considerably more sensitive than earlier patterns. Scheller † investigates the properties of four big aperture objectives of short focal length with reference to their suitability for variable star work. A simple stellar photometer is described by Steavenson.‡

Novæ.—N Pictoris has been discussed by Spencer Jones in several papers. One of these § has been described as "the most complete study of a single nova up to the present." A full description is given of all spectra photographed at the Cape, together with some objective prism photographs taken at Johannesburg. The development of the nova was rather unusual, a remarkable feature being the appearance of three or four separate nuclei. Micrometer measures of these have been given by van den Bos and Finsen.‖ The existence of the fourth component was doubtful. The measures show that the separations AB and AC increased, while it is noted that B and C faded more rapidly than A.

The later spectrum of this nova is described by Spencer Jones, ¶ the final stage being similar to a Wolf-Rayet spectrum, with unidentified strong emission lines at $\lambda\lambda$ 5723 and 6087. The continuous spectrum was fairly strong and the Balmer decrement high. Jones also discusses the parallax of N Pictoris.** Trigonometrical measures at the Cape gave $-0''{\cdot}009 \pm 0''{\cdot}007$. By assuming a surface brightness and correlating the observed increase of luminosity with the rate of expansion given by spectrographic data a parallax $0''{\cdot}0015$ is derived. This value gives the absolute visual magnitude at maximum as $-7{\cdot}9$.

In another paper †† Jones estimates the parallaxes of N Persei (1901) and N Ophiuchi (1918). The first is deduced from observations of the rate of expansion of the small surrounding nebulosity, discovered by Barnard and photographed by Ritchie in 1917, together with the spectrographic rate of expansion. The parallax is $0''{\cdot}00205$ (compared with earlier estimates $0''{\cdot}011$) and the corresponding absolute magnitude at maximum $-8{\cdot}3$. The N Ophiuchi parallax is derived from the displacement of the interstellar calcium lines, which is assumed to be due solely to solar motion and galactic rotation. The value is $0''{\cdot}00029$ and the maximum absolute magnitude $-5{\cdot}5$.

* Bernheimer, *Lund Meddelande*, Series II, No. 61.
† Schneller, *Veroff. Universitätssternwarte zu Berlin-Babelsberg*, **8**, pt. 6.
‡ Steavenson, *M.N.*, **92**, 839.
§ Spencer Jones, *Annals of the Cape Observatory*, **10**, pt. 9.
‖ van den Bos and Finsen, *M.N.*, **92**, 19.
¶ Spencer Jones, *M.N.*, **91**, 777 ; **92**, 728.
** Spencer Jones, *M.N.*, **91**, 608. †† Spencer Jones, *Observatory*, **55**, 251.

Beals * applies to N Aquilæ and P Cygni, as well as certain Wolf-Rayet stars, the method of temperature determination proposed by Zanstra for planetary nebulæ. The temperatures derived are minimum values. The result for N Aquilæ is 60,500°, and for P Cygni (two separate determinations) 16,000° and 23,000°. The same author † has also measured band contours in N Aquilæ and N Cygni, and maintains that, as with Wolf-Rayet spectra, the characteristic feature of these bands is a flat top. He shows that such a flat top may be expected if the emitting atoms are being ejected from the star uniformly in all directions and with a comparatively small scatter in velocities. Criticism of this work has been made by Genard. ‡ §

Microphotometer tracings of spectra of N Aquilæ (1918), taken at Mt. Wilson before maximum, have been examined by Wilson,‖ who fails to find an expected asymmetry in the lines. Stratton ¶ suggests identification of previously unknown novæ lines at about λλ 4606 and 4623, with NV lines given by Edlén.

The Andromeda nebula has been photographed regularly at Mt. Wilson during the past three years in the hope of finding novæ sufficiently bright for spectra to be obtained. Two such objects were discovered in the summer of 1932. Humason ** states that, as far as the extremely small dispersion used will permit examination, the spectra are similar to those of galactic novæ. The photographic absolute magnitudes at maximum were −6·5 and −6·2. Other novæ recently found in this nebula are recorded by Mayall.††

Berman ‡‡ has studied T Coronæ, which was a nova in 1866, with regard to both spectrum changes and colour temperature. All traces of nova parentage have disappeared. The spectrum is now gM3, and the colour temperature, measured by comparison with ζ Ophiuchi, was found to be 3000° K. Objective prism spectra of N Aquilæ (1918) and N Persei (1901) have been obtained by Bruck, §§ who finds no Wolf-Rayet bands in either. Steavenson |||| has observed old novæ for light variations.

Cepheids and Cluster Variables.—A photometric examination of the spectra of η Aquilæ and δ Cephei, with determination of colour temperatures and line contours, has been made by Whipple.¶¶ Following a method suggested by Baade, the usual radiation laws are assumed and relative changes of radius derived from the observed temperature and luminosity variation. Assuming pulsation, a comparison with radial velocity data gives the actual value of the radius, and hence the absolute magnitude and parallax. These "pulsation parallaxes" are found to be about three times as great as the usually accepted values, a discrepancy taken to be evidence against the pulsation theory. It is possible that Planck's radiation law is not obeyed, but it is pointed out that the colour temperature seems to bear the same

* Beals, *M.N.*, **92**, 677.
‡ Genard, *M.N.*, **92**, 396.
‖ Wilson, *P.A.S.P.*, **44**, 388.
** Humason, *P.A.S.P.*, **44**, 381.
‡‡ Berman, *P.A.S.P.*, **44**, 318.
|||| Steavenson, *M.N.*, **91**, 941 ; **92**, 720.
† Beals, *M.N.*, **91**, 966.
§ Beals, *M.N.*, **92**, 885.
¶ Stratton, *Observatory*, **55**, 207.
†† Mayall, *P.A.S.P.*, **43**, 217.
§§ Bruck, *Z.f.Ap.*, **4**, 70.
¶¶ Whipple, *L.O.B.*, No. 442.

relation to spectral type in these Cepheids as in normal giants. A suggestion by Menzel * that Cepheid variation is due to the appearance of hot spots on the surface (with perhaps pulsation as well) is discussed, but any decision must await the more precise determination of spectral energy distribution.

Line contours were measured on 3-prism spectrograms, and from these log N and log g were calculated, N being the number of atoms above optical depth 0·5, and g the gravitational acceleration. Log N remains satisfactorily constant for *Ca*, *Fe* and *Mn*, but there are discrepancies with *SrII* and *H*. The *SrII* figures might be explained by assuming a relative abundance about twenty times that in the Sun. The values of log g are very discordant and vary far more than the pulsation theory will permit. It is possible to remove the difficulty by assuming a sufficiently great abundance of hydrogen, but then there should be marked absorption at the Balmer limit. The actual absorption in Cepheids appears to be no greater than that in the Sun.

Krieger † also has made spectrophotometric observations of η Aquilæ, determining the temperature both from spectral type and from colour distribution. The agreement is not close. Assuming the differences of spectral type (estimated chiefly from atomic ionization) observed at equal temperatures to be due to differences of pressure, the variation of electron pressure is calculated from Saha's equation. It changes by a factor 10^2 or 10^3, the phase appearing to agree with that of the radius as computed by Baade from magnitude and temperature. Similar work was done on Y Ophiuchi, where P varied between $\frac{1}{7}$ and $\frac{1}{500}$ the value for a normal giant. There is a tendency, slight in Y Ophiuchi but well marked in η Aquilæ, for temperatures on the ascending branch of the light curve to be higher than at equal magnitudes on the descending branch.

The importance of intensive study of individual Cepheids as more likely to produce insight into the general problem of these stars than the accumulation of vast numbers of visual or photographic light curves is emphasized by ten Bruggencate.‡ He has on this account selected eight particularly interesting Cepheids for special study, and here publishes results for three, viz. Y Sagittarii, U Sagittarii and Y Ophiuchi. Using objective prism spectra in the region λλ 4000–4500, he finds, as Krieger does, that the temperature is higher on the ascending branch than at corresponding points of the descending branch. The intensity of the hydrogen lines is greater on the ascending branch than at points of equal colour temperature on the descending branch. It is concluded that the colour temperature given by this region of the spectrum is not the true temperature of those parts of the star's atmosphere concerned. Brill § criticizes this work, chiefly on account of the small dispersion and the short range of spectrum used. He shows that the intensity changes measured by ten Bruggencate in each of the three spectra cannot be represented by a simple variation of colour temperature.

* Menzel, *Pop. Ast.*, **39**, 16.
† Krieger, *Ap. J.*, **74**, 10 ; **75**, 147.
‡ ten Bruggencate, *Annalen v. d. Bosscha-Sterrenwacht, Lembang*, **5**, pt. 1.
§ Brill, *Z.f.Ap.*, **4**, 19.

ten Bruggencate * attributes this to accidental errors unavoidable with his instrumental equipment.

The intensities of *CH* and *CN* bands in spectra of δ Cephei have been measured by Swings,† who finds that there is variation with the light curve and that the bands are brighter on the descending branch than at points of equal luminosity on the ascending branch. It is shown that the intensity of the *CH* band should vary chiefly with the square root of the number of absorbing molecules. Calculation of the relative numbers of molecules at various temperatures by means of a dissociation formula gives close agreement with the numbers derived from intensity measures.

The complicated radial velocity variation of S Sagittæ has been studied by Aldrich,‡ who finds three separate oscillations with periods 8·38, 4·19 and 682 days. At Ann Arbor investigations have been continued into the problem of variation of velocity at different levels in the atmospheres of Cepheids,§ but although differences are found, the results are not very decisive.

The question of the phase relation between light variation and radial velocities remains a difficulty in the pulsation theory. It has been examined from the observational side by Robinson and Miss Hoffleit,‖ who find that maximum light and maximum velocity of approach do not always occur simultaneously, and that maximum velocity of recession does not always coincide with minimum light. Within the limits of error, maximum velocity of approach never precedes maximum light, and maximum velocity of recession never precedes minimum light. The lag of maximum velocity of approach is not a function of period, but is apparently correlated with peculiarities of light variation and spectrum. The difficulty of reconciling pulsation theory with observation in this matter is discussed at some length by Siedentopf,¶ who is of the opinion that the solution is to be found in the star's atmosphere.

The zero of the period-luminosity relation continues to attract attention. Observational data, although improved, are still more meagre than could be desired. However, Gerasimovič ** has taken the available proper motions and radial velocities and deduced mean parallaxes along the usual lines, taking into account a galactic rotation term. There results a correction $+1^{m}\cdot0$ to Shapley's original curve ($+0^{m}\cdot8$ to his corrected curve), with an estimated uncertainty not exceeding $0^{m}\cdot2$. Nordström †† considers that Gerasimovič should have taken individual star distances, instead of a mean value, when introducing the galactic rotation term. Doing this he reduces the correction from $+1^{m}\cdot0$ to $+0^{m}\cdot6$; but Gerasimovič points out ‡‡ that this correction, although it decreases π_{par}, also decreases the peculiar motions of the stars and increases π_{pec}, so that the final zero correction

* ten Bruggencate, *Z.f.Ap.*, **4**, 33.
† Swings, *M.N.*, **92**, 140.
‡ Aldrich, *Pub. Obs. Univ. of Michigan*, **4**, 75.
§ Rufus, *ibid.*, **4**, 101, 151 ; Lee, *ibid.*, **4**, 109.
‖ Robinson and Hoffleit, *H.B.*, **888**, 12.
¶ Siedentopf, *A.N.*, **244**, 17 ; **245**, 85.
** Gerasimovič, *A.J.*, **41**, 17.
†† Nordström, *Lund Circular*, **2**, 27.
‡‡ Gerasimovič, *Lund Circular*, **4**, 67.

is substantially unaltered.* The problem has been approached in another way by Kipper,† who compares the change of apparent diameter derived from total brightness and colour-index data with the diameter variation given by radial-velocity observations. Calculating in this way the distances of a number of Cepheids, he finds that Shapley's original relation requires a zero correction $+1^{m}.1$.

Besides the period-luminosity relation there are correlations between several of the other observable characteristics of these stars, *e.g.* period, spectrum, amplitude, form of light curve, etc. These correlations have been investigated by Sticker‡ and by Lundmark.§ Other work on Cepheids published during the past two years has been concerned with secular changes of period and of luminosity.‖ These changes, if they exist, are extremely small.

Miss Sawyer,¶ in the course of work on variables in the globular clusters N.G.C. 362, 6121 and 6397, finds in N.G.C. 362 three classical Cepheids which seem definitely to belong not to the cluster, but to the Small Magellanic Cloud, which must therefore extend much further in this direction than had been supposed. Four classical Cepheids are found with periods 1·0 – 1·5 days, bringing the total number known in that range to ten. It is thought that further study of faint variables in this part of the sky will help to close the gap between cluster variables and classical Cepheids. Two cluster variables in this region probably belong to the galaxy and must be about 10,000 parsecs from the galactic plane. Baade** also mentions a number of these objects very far removed from the galactic plane. He suggests that these isolated stars extend through the same region of space as the globular clusters, and are probably physically related to the latter.

Intermediate Stars.—Radial velocities and spectrographic observations of variables whose periods lie between those of the Cepheids and the long-period variables are now becoming available.†† Twenty-two RV Tauri stars have been observed at Mt. Wilson. During the light period their spectra vary from type F or G to K. Hydrogen emission lines and titanium oxide bands are often present. There is velocity variation in most cases, but the amplitude is less than with the Cepheids.

Observations have also been made of 22 intermediate stars of M type. Their spectra are similar to those of the Me variables, but are without emission lines. No spectral changes have been observed, and the radial velocity variation is small.

There seems to be no connection between the spectra of the G and M variables of intermediate period, except that they all indicate high luminosity. The velocities are much higher, although showing less variation, than for Cepheids. It is pointed out that these intermediate variables are not

* Nordström, *Lund Circular*, **4**, 78.
† Kipper, *A.N.*, **241**, 249.
‡ Sticker, *Z.f.Ap.*, **2**, 389.
§ Lundmark, *Z.f.Ap.*, **3**, 313; *Lund Circular*, **7**, 150.
‖ Nielsen, *A.N.*, **243**, 409; **244**, 333; Kukarkin and Florja, *Z.f.Ap.*, **4**, 247; Zinner, *Sitz. Preuss. Akad. Wiss.*, 1931, 182.
¶ Sawyer, *H.C.*, **366** and **374**.
** Baade, *A.N.*, **244**, 153.
†† Joy, *P.A.S.P.*, **44**, 240.

concentrated to the galaxy, and that those of M type are rarely found between galactic longitudes 180° and 360°.

Radial velocity observations of individual variables of this class have been published by Joy,* Sanford † and Redman.‡

Long-period Variables.—Apart from the regular light-curve observations comparatively little work on these stars has been published recently. Estimates of the variations of the lines λ 4227 *CaI* and λ 3968 *CaII* have been made by Miss Hughes.§ Ionization as measured by the intensities of these lines reaches its maximum and minimum at the same time as the light curve. There is no correlation between the ionization curves and either the period or the form of the light curve. Neither does there appear to be any relation between the total strengths of the lines and the period. The titanium oxide variation is closely parallel to that of λ 4227.

Plakidis ‖ continues work on the irregularities of period of these variables, using more extended data than heretofore. A note on his work is added by Eddington.¶ It appears that with most of these stars the irregularities are small and accidental. Three are found to have changing periods, while with two others there seems to be a tendency for irregularities to repeat.

The positions of 241 stars, mostly long period and irregular variables, are given by Palmér,** together with proper motions for 117 of these objects. Ludendorff †† has studied the light curves of Mira variables along lines similar to those followed in his article in the *Handbuch der Astrophysik*, but with more extensive data.

Eclipsing Variables.—Details of extensive spectrographic observations of ε Aurigæ made at the Yerkes Observatory, particularly during recent years, are given by Frost, Struve and Elvey.‡‡ Wave-lengths, intensities and identifications of the spectrum lines are given, and a discussion is made of the radial velocities. A systematic deviation of the latter from the values expected from the orbital motion was found during eclipse, and was traced to an asymmetry of most of the lines. λ 4481 *MgII* was a prominent exception not sharing in this effect. (The lines were probably actually double, and with greater resolving power would have been separated as they were at Mt. Wilson.) The asymmetry is suggested to be due to a rapidly rotating secondary of type similar to the primary, but without *MgII*, with an atmosphere very flattened at the poles and extended at the equator, or to a tidal bulge on the primary. The contour of *Hβ* was measured. At first it had 100 per cent. central absorption, and fitted Unsöld's theory closely. Later, however, it showed signs of change, and only 72 per cent. central absorption was found. Further observations through another cycle are needed.

Photo-electric measures of this star were made by Huffer §§ throughout

* Joy, *Ap. J.*, **75**, 127.
† Sanford, *Ap. J.*, **73**, 364.
‡ Redman, *M.N.*, **92**, 116.
§ Hughes, *H.B.*, **882**, 23.
‖ Plakidis, *M.N.*, **92**, 460.
¶ Eddington, *M.N.*, **92**, 470.
** Palmér, *Lund Meddelande*, Series II, No. 66.
†† Ludendorff, *Sitz. Preuss. Akad. Wiss.*, 1932, 291.
‡‡ Frost, Struve and Elvey, *Pub. Yerkes Obs.*, **7**, pt. 2.
§§ Huffer, *Ap. J.*, **76**, 1.

the eclipse of 1928–30. The mean magnitude on each night was determined with a probable error $\pm 0^m.006$. Irregular secondary oscillations were observed with an amplitude up to $0^m.2$, but no correlation could be established between these and small spectrum variations during the same interval. There was a steady decrease of brightness amounting in all to about $0^m.06$ during the "constant" phase of minimum. The upper limit of density of the primary is computed to be 5.6×10^{-7}. Jacchia * also gives photometric measures of this star, and notes that the decrease at the beginning of eclipse seemed rather quicker than the increase at the end.

ζ Aurigæ, a remarkable spectroscopic binary with composite spectrum K5+B, has been discovered to be also an eclipsing variable, not unlike ϵ Aurigæ in some respects.† The period is 973 days, and there is a shallow eclipse lasting between 30 and 50 days. Spectrographic observations at the end of eclipse showed a remarkable variation of intensity of the K line, which is supposed to have been formed by the light from the B star shining through the atmosphere of the K companion. Using the displacements of the K line, it has been possible to estimate the absolute dimensions of the system. For the K star, the most interesting of the pair, the mass is around $30\odot$, absolute visual magnitude $-3^m.5$ and radius approximately 175×10^6 km. The next mid-eclipse is on 1934 September 13, and further spectrographic observations are most desirable. Müller ‡ has investigated the variability of this object from earlier measures of ϵ Aurigæ, in which it was used as a comparison star.

The eclipsing variable Y Cygni is of peculiar interest on account of the possible light it may throw on the distribution of density within a star. Dugan § has published a discussion of the very extensive photometric data referring to this star, including 13 years' intensive observations by himself. The eclipse observations for the past 45 years are closely represented on the assumption of a revolution of the line of apsides, of an amount in very satisfactory agreement with spectrographic measures. Absolute dimensions of the system are given, and reference is made to the difficulties still to be cleared up, particularly in connection with a third body which appears to be indicated by the spectrographic work. This last point has also been discussed by Redman.||

A method is given by Uitterdijk ¶ whereby limits may be derived for the eccentricity and longitude of periastron of an eclipsing binary. The method is illustrated by a new eclipsing variable where $.229 < e < .236$. The reflection effect in eclipsing binaries has been investigated by Pike.** The question of phase difference between the observed time of eclipse and the time of

* Jacchia, *A.N.*, **241**, 415.

† Guthnick and Schneller, *Sitz. Preuss. Akad. Wiss.*, 1932, 57 ; see also *A.N.*, **245**, 9, 11, 279.

‡ Müller, *A.N.*, **245**, 393.

§ Dugan, *Contributions Princeton Univ. Obs.*, No. 12.

|| Redman, *Observatory*, **54**, 195.

¶ Uitterdijk, *B.A.N.*, **6**, 241.

** Pike, *Ap. J.*, **73**, 205.

conjunction given by spectrographic elements is examined by Carpenter,* and a method is given of computing corrections to the spectrographic orbit on this account.

Absolute dimensions from spectrographic and photometric elements have been computed for RT Lacertæ,† TT Aurigæ, ‡ AG Persei and RR Lyncis.§

Peculiar Stars.—A radial velocity curve of 27 Canis Majoris covering the years 1925–31 is given by Struve.‖ The period is at least 2000 days, and the amplitude 220 km./sec. If the velocity variation is due to orbital motion the minimum mass is 2000⊙. There are double emission lines of hydrogen of variable intensity, and striking changes in the strengths of absorption lines are found. In view of these, it is possible that the observed radial velocity changes are not due to orbital motion, a view supported by McLaughlin,¶ who suggests that the star is a normal Be variable, line displacements being due to variable emission. Struve ** is not convinced that the absorption-line shifts can be explained in this way. He points out that although the orbital assumption may be questioned, principally on account of the enormous minimum mass, no other explanation is without its own difficulties.

A new variable star with period about 100 minutes has been discovered by van Gent.†† Confirmatory observations have been made at Mt. Wilson.‡‡

Studies have been made, principally at the Yerkes Observatory, of the variations of absorption lines in certain spectroscopic binaries.§§ The Be stars, in which the emission lines are usually variable, have been investigated by workers at Ann Arbor,‖‖ and certain remarkable Be variables have been observed by Merrill.¶¶

A spectrum of P Cygni, photographed at the coudé focus of the 100-inch reflector at Mt. Wilson, shows double absorption lines of hydrogen as well as other interesting details of structure.***

R. O. R.

* Carpenter, *P.A.S.P.*, **43**, 30.
† Joy, *Ap. J.*, **74**, 101.
‡ Joy and Sitterley, *Ap. J.*, **73**, 77.
§ Huffer, *Pub. Washburn Obs.*, **15**, pt. 4.
‖ Struve, *Ap. J.*, **73**, 301.
¶ McLaughlin, *Ap. J.*, **75**, 60.
** Struve, *Ap. J.*, **75**, 158.
†† van Gent, *B.A.N.*, **6**, 93.
‡‡ Mayall, *P.A.S.P.*, **43**, 304.
§§ Morgan, *Ap. J.*, **74**, 24; **75**, 407, 423; **76**, 275, 315; Farnsworth, *ibid.*, **75**, 364; **76**, 313; Struve, *ibid.*, **76**, 85.
‖‖ Curtiss, *Pub. Obs. Univ. of Michigan*, **4**, 163; McLaughlin, *ibid.*, **4**, 175; Losh, *ibid.*, **4**, 199.
¶¶ Merrill, *Ap. J.*, **73**, 348; **75**, 131, 413.
*** *P.A.S.P.*, **43**, 402.

Double Stars

The most important event in 1932 connected with double stars was the publication of Dr. R. G. Aitken's general catalogue. This work is an extension of Burnham's, and summarises all double star measures between 1905 and the beginning of 1927. Reference might here be made to the presidential address on the award of the gold medal of the Society to Dr. Aitken (*M.N.*, **92**, 354), and the George Darwin lecture, "What we know about Double Stars," by Dr. Aitken (*M.N.*, **92**, 596).

Vol. 6 of the *Annals* of the Bosscha Observatory, Lembang, Java, contains the third series of measures by Dr. Voûte, made in the period 1927 January to 1932 November. This is an extremely valuable publication, as it is confined to very important stars—binaries showing orbital motion or stars with a separation under 1″. The stars lie mostly between the equator and declination −65°. In all there are 3913 observations of 855 pairs. Measures were made with and without reversion prism, and for each night's measures of each star the difference of the measures with and without prism is given so that the effect of the prism can be investigated. There is a short discussion of the results. It may be noted here that increasing use is being made of a reversion prism by double star observers. It has generally been used by the Johannesburg observers in the measures referred to in the next paragraph.

Circulars 86, 87 and 88 of the Union Observatory, Johannesburg, show the activity of Dr. W. H. van den Bos and Mr. W. S. Finsen. The thirteenth series of measures is due to Finsen, and includes 10 new pairs, 9 less important pairs and 1076 measures of 278 pairs, mostly discovered by the Johannesburg observers. There are two series of measures by van den Bos in *Circulars* 87 and 88, the first containing 1905 measures of 458 stars and the latter 1717 measures of 408 stars. These lists include many close double stars.

A publication from the Flower Observatory, Philadelphia, is entitled "1414 Measures of 1033 Double Stars," by Professor Olivier and other members of the staff. The volume actually contains some 4000 measures if the number of nights of observation of the various stars are counted separately. S. G. Barton gives in this catalogue a list of 41 double stars found on Tacubaya astrographic plates; an additional 33 are given by him in *A.J.*, 981.

The Greenwich volume for 1930 gives on pages B. 2–9 the measures of 176 stars. The stars are fairly close ones, and each star was measured on at least 3 nights.

Öpik gives, in *Publications of Tartu Observatory*, **27**, No. 5, measures of some 450 wide double stars. Most stars were measured on 2 nights.

Journal des Observateurs, **15**, 96, 145, gives two instalments of 1992 measures of 381 double stars by P. Baize and Mme. Igounet. The stars are mostly Σ, OΣ or β.

Two series of measures of double stars on photographic plates taken with

the Sheepshanks Coudé refractor (focal length 19·3 feet) at Cambridge are given by Dr. W. M. Smart in *M.N.*, **92**, 37, 207. These lists contain 177 and 263 stars respectively. More than half are in Burnham's catalogue, others are fainter.

Other double star measures published in 1932 are as follows :—

Observer	Reference	No. of Stars	Notes
Aller, R. M.	*A.N.*, 245, 213	125	Miscellaneous.
Armellini, G.	*A.N.*, 245, 373	28	Miscellaneous.
Barbier, D.	*Journ. d. Obser.*, 15, 52	49	Miscellaneous.
Bemporad, A.	*A.N.*, 244, 353	42	Catania Astr Cat., 48° to 52°.
,,	*A.N.*, 246, 23	34	
Espin, T. E., and Milburn, W.	*M.N.*, 92, 214	99	New.
		59	New.
		63	Miscellaneous.
Giaccobini, M.	*Journ. d. Obser.*, 15, 29	64	New, faint.

Orbits.—The following table gives new orbit determinations with the more interesting elements :—

Computer	Reference	Star	*P* Years	*a* ″	*e*
Aitken, R. G.	*P.A.S.P.*, 44, 127	83 Aquarii	22·0	0·20	·35
,,	*P.A.S.P.*, 44, 129	24 ,,	46·6	0·41	·85
Finsen, W. S.	*U.O.C.*, 86	I 65	16·5	0·315	·586
,,	*U.O.C.*, 88	Hu 298	30·0	0·242	·238
Fletcher, A.	*M.N.*, 92, 121	61 Cygni	697·0	24·525	·404
Halpern, J. L.	*A.J.*, 976	Σ 1306	...	...	...
Van den Bos	*U.O.C.*, 88	OΣ 77	53·95	...	·960

Fletcher's work is interesting as it concerns a star of large parallax. It is unique in so far as the parallax and the mass-luminosity law are used to assist the orbit determination which rests on a small but well observed arc. In *M.N.*, **92**, 119, he discusses the effect of proper motion on radial velocity measures.

The observations of Σ 1306 are as well represented by a parabola as by an ellipse ; for a parabola, $q = 1''{\cdot}054$. If e is taken as 0·96, $q = 1''{\cdot}020$, $a = 25''{\cdot}50$, $P = 10850$ years.

OΣ 77 is an interesting but difficult star, and the result obtained depends on which of the early observations are altered by 180°. In *P.A.S.P.*, **44**, 132, Aitken points out that OΣ 65 is now a very close pair, and that the period must be 60 to 65 years and the eccentricity large.

In *L.O.B.*, 443, L. Berman makes a study of 70 Ophiuchi as a triple system from radial velocity observations. He concludes that there is a dark star forming a binary of period 18 years with the principal component of the visual double. From a combination of visual and spectroscopic observations he deduces the parallax as $0''{\cdot}179 \pm 0''{\cdot}008$, and finds the small value of 0·1 to 0·2 for the mass of the dark star. Measures of 70 Ophiuchi from photographic plates are published by D. Reuyl in *P.A.S.P.*, **44**, 375.

Van den Bos in *U.O.C.*, 86, gives supplementary notes to his paper in *U.O.C.*, 68, on the derivation of orbital elements.

General.—In an extensive investigation into the evolution of binary stars published in *Ap. J.*, **75**, 69, W. Markowitz concludes : "If there are no forces acting on a binary which tend to increase *P*, *a*, *e* other than those due to tides, secular decrease of mass and close encounters, then, in general, *P*, *a*, *e* are decreasing."

A discussion of the various formulæ for determination of dynamical parallax is given by Finsen in *M.N.*, **92**, 47. The question of systematic errors in dynamical parallaxes has been brought forward by Barbier in *Journ. des Obser.*, **15**, 3, but his results have been criticised by Finsen in *M.N.*, **93**, 24, in a paper on the reliability of hypothetical parallaxes.

J. J.

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ADDRESS

Delivered by the President, Dr. H. Knox-Shaw, on the Distances and Motions of the Extra-Galactic Nebulæ.

In this address I shall make an attempt to summarize our knowledge of the distances and motions of the extra-galactic nebulæ, especially in the further light thrown on the problem by the new Harvard catalogue of nebular magnitudes. But before coming to the subject proper, it will be well, I think, if we refresh our memories as to the various types of nebula with which we shall have to deal.

The classification now generally adopted is that put forward by Dr. Hubble in 1925 (Table I). He divided the extra-galactic nebulæ into three main classes: Elliptical nebulæ, Spirals and Irregular nebulæ; the spiral class further into normal and barred spirals; and each of these subdivisions again into "early," "intermediate" and "late." The classification is essentially descriptive in nature, depending only on the forms of the nebulæ as shown by the photographic plate, but it is so reminiscent of the line of evolution laid down by Sir James Jeans from theoretical considerations that Hubble felt justified in employing terms suggestive of a sequence in time. They are not, however, essential to the scheme, and if preferred the letters *a*, *b* and *c* can be used in their place, as indeed they are in the symbolic form.

TABLE I

Classification of Extra-Galactic Nebulæ

Type	Symbol
ELLIPTICAL	E
SPIRALS:	
Normal Spirals—	S
(*a*) Early	Sa
(*b*) Intermediate	Sb
(*c*) Late	Sc
Barred Spirals—	SB
(*a*) Early	SBa
(*b*) Intermediate	SBb
(*c*) Late	SBc
IRREGULAR	Irr

The sequence runs from the elliptical nebulæ, in which the nebulosity is entirely unresolved and structureless, through the early type, in which spiral structure first appears combined with a large and unresolved nucleus, to the late type, where the nucleus has become small and is sharply defined, and the arms of the spiral have unwound and can be resolved into numerous condensations or even stars. In the barred spirals the arms appear to

emerge, not from the nucleus itself, but from the ends of a bar of nebulosity which stretches across the nucleus. Finally, at the end of the sequence, or outside it altogether, are the comparatively few nebulæ which are classified as irregular, since they appear to lack any rotational symmetry and have no recognizable nucleus. Those near neighbours of ours, the Magellanic Clouds, are included in this class.*

The distances of the nebulæ have been determined by Hubble in one of three ways: from the apparent magnitudes (*a*) of identified stars in the nebulæ, (*b*) of the brightest stars in them, or (*c*) of the nebulæ themselves. The use of the first method is dependent on being able not only to detect a star in the nebula, but also to identify its type. The second method is employed when stars can be recognized as such, but not classified. All but a comparatively few of the nebulæ fall into neither of these categories, and for their distances recourse is had to the third method.

Nebulæ in which stars of recognized type have been found are very few in number. Hubble and Humason in their comprehensive paper published in 1931 † list only eight such. In these nebulæ the stars most commonly identified have been Cepheids, and on them the determinations of distance depend. A number of novæ and a few irregular variables, helium stars and P Cygni stars have also been detected, and such evidence as they afford is confirmatory of the general order of distance given by the Cepheids. The Andromeda nebula, of which Hubble has made an exhaustive study based upon 350 plates taken over a period of 18 years, may be cited as an example. In this nebula some 50 variable stars have been found, of which 40 have been identified as Cepheids, from their light curves and from the fact that they show the customary relationship between period and luminosity. The number of novæ which have been detected is about 85. Those of them that have been caught before attaining their maxima show the quick rise to this point followed by a slower decline and final disappearance, which is characteristic of novæ in the galaxy. Using the distance of the nebula derived from the Cepheids, the mean absolute magnitude of these novæ at maximum is found to be about $-5{\cdot}5$, a value which is shown by our knowledge of similar stars in the galaxy, meagre though this is, to be of the right order.

All distances derived from Cepheids are affected, of course, by the uncertainty in the zero of the period-luminosity relation. The present adopted form of the relation, as given by Shapley in his book *Star Clusters*, ascribes to Cepheids with periods of one day and ten days absolute magnitudes of $-0{\cdot}3$ and $-1{\cdot}9$ respectively. Although there is fairly general agreement as to the form of the curve, except perhaps at its two ends, its zero has been the subject of much discussion. It will be recalled that the galactic Cepheids, upon the distances of which this zero depends, are too remote to have reliable trigonometrical parallaxes, and that in consequence their distances, being derived largely from their proper motions, are subject to considerable uncertainty. The question is much too large a one to enter upon in any detail now. I must confine myself to the barest summary.

* Slides were shown to illustrate the various types of nebula.

† *Ap. J.*, 74, 43, 1931.

Most of the criticisms of Shapley's zero suggest the need of a positive correction of the order of half a magnitude. This is, however, without taking into account the effect of any absorption in the plane of the galaxy, and the adoption, for instance, of Trumpler's value of $0^m.67$ (photographic) per kiloparsec would entail a negative correction to the zero point of about $0^m.3$. Shapley himself has expressed the opinion that the correction to his present zero will never exceed a quarter of a magnitude and that it may be in either direction. This is equivalent to saying that the scale of distances based on the relation, as now adopted, is correct to within 12 per cent.

TABLE II

Extra-Galactic Nebulæ

Distances from Identified Stars

Nebula	Distance (megaparsecs)	Absolute Magnitude of Brightest Stars
Large Magellanic Cloud	0·026	−7·6
Small Magellanic Cloud	·029	−5·8
N.G.C. 6822	·192	−5·6
N.G.C. 598 (M. 33)	·236	−6·3
N.G.C. 224 (M. 31)	·247	−5·8
N.G.C. 5457 (M. 101)	·40	−6·0
N.G.C. 2403	·63	−6·0
N.G.C. 3031	·73	−5·8
	Mean Value	−6·1

The distances derived by Hubble for the eight nebulæ from the Cepheids involved in them are given in Table II. The third nebula in the list, N.G.C. 6822, is of the irregular type and greatly resembles the Magellanic Clouds. The last five nebulæ are normal spirals, N.G.C. 224 (the Andromeda Nebula) and N.G.C. 3031 being of intermediate, and the other three of late, type. In the last column of the table will be found the absolute magnitudes of the brightest stars in the nebulæ, based upon the distances derived from the Cepheids. The scatter around the mean value of −6·1 is reasonably small, and would be remarkably so, if it were not for the case of the large Magellanic Cloud.

The assumption that −6·1 might be taken as the absolute magnitude of the brightest stars in all extra-galactic nebulæ enabled Hubble to determine the distances of some thirty more such objects, in which he could detect stars, though he was unable to identify them as belonging to any particular class. He actually adopted the value −6·0, for reasons which I need not specify, as they no longer seem valid. The difference is clearly of no great importance. The criticism has been made that what have been taken to be stars may not be in reality single stars but groups or small clusters of stars. Hubble has, however, expressed himself as confident that this is not the case, and in view of his extensive experience with photographs taken with large reflectors, his opinion is, I think, entitled to considerable

weight. If they are actually small clusters, the absolute magnitude found for them seems unreasonably faint, but in other respects the determination of distance by means of them is in no way invalidated. The statement by de Sitter in his recent book *Kosmos*, that by assuming they are clusters we could increase our scale of distances tenfold, and thus reconcile the size of the nebulæ with that generally accepted for our own galaxy, seems to be based on a misunderstanding as to how the adopted absolute magnitude of $-6{\cdot}1$ has been determined.

For the nebulæ other than the few in which stars could be detected Hubble had to choose between the apparent magnitude and the apparent size as a criterion of distance. He came to the conclusion that the total luminosity of a nebula derived from its image on a photographic plate is much less dependent on the size of the telescope, the speed of the plate and the length of the exposure, than are its apparent dimensions, largely because so much of the light is in general concentrated near the centre. Thus failure of the outer parts of a nebula to impress themselves on the plate will have less effect on the total luminosity than on the size of the photographic image. This is especially the case, of course, with the elliptical nebulæ and early spirals, but in the later types the arms are often so much unwound that the size of the object is not a good indication of its mass. The assumption underlying this method of determining distance is that the nebulæ are all of the same intrinsic luminosity, or at any rate, for it to be of use statistically, that there is a most favoured value of the absolute magnitude, about which the dispersion is not unduly large. To determine this value, Hubble listed the differences between the apparent magnitudes of the nebulæ and those of the brightest stars in them, in the forty cases where he had found stars. These differences in conjunction with the mean absolute magnitude of the brightest stars, already found from the nebulæ containing Cepheids, at once provided absolute magnitudes for the nebulæ themselves.

The chief difficulty lay in obtaining a reliable system of apparent magnitudes of the nebulæ. In the absence of any such determined photographically, Hubble had perforce to fall back upon a series of visual observations made by Holetschek with a small refractor some twenty-five years ago. These magnitudes with certain scale corrections applied by Hopmann formed the most homogeneous system available, but nevertheless they could not be regarded as really suitable for the purpose in hand. The photometry of surfaces such as the nebulæ present is a difficult subject upon which a good deal of work is now being done at Mount Wilson and elsewhere, both photographically by means of extra-focal images and also with the photo-electric cell. Doubtless in a few years' time we shall have gone a long way towards solving the problem. In the meantime there has quite recently appeared in the *Harvard Annals* * a catalogue of 1249 extra-galactic nebulæ with their photographic magnitudes determined on a uniform system. It is the work of Professor Shapley and Miss Ames, and is complete down to magnitude 13 over the whole sky. The magnitudes have been derived from focal images, and it is held by some that magnitudes of nebulæ so

* *H.A.*, 88, 2, 1932.

determined cannot be satisfactory. The plates used, however, were those of the "Harvard patrol," taken with lenses of 2 inches aperture, and having the small scale of 10′ to the millimetre. On these the images of all but a few of the larger nebulæ are sufficiently stellar in character to rob their comparison with those of the stars of much, if not all, of the difficulty inherent in the same process on plates of large scale. Whatever its shortcomings may be, it must, I think, be agreed that this catalogue provides a much more satisfactory system of nebular magnitudes than those of Holetschek. It has the additional advantage that its magnitudes are photographic. With their employment the whole of the work is on a photographic basis, and the necessity of determining and applying a colour index is obviated.

TABLE III

Values of $m_s - m_n$

Type	All 40 Nebulæ		Those with Reliable Mags.		
	Hubble	No.	Hubble	No.	Revised
Sb	9·6	12	9·5	10	8·6
Sc	8·7	22	8·8	19	8·4
Irr	8·0	6	7·6	3	7·6
All	8·9	40	8·9	32	8·4
Range	$4^m{\cdot}9$		$3^m{\cdot}8$		$2^m{\cdot}1$
Av. Resid.	± ·77		± ·71		± ·47

I have consequently substituted magnitudes from the new Harvard catalogue in the place of those used by Hubble, and a comparison of the results is given in Table III. In the first part of the table will be found Hubble's mean values for the difference between the apparent magnitudes of the brightest stars and those of the nebulæ themselves for each of the three types represented. Hubble drew attention to the variation with the type and suggested that it might be significant. He found the total range to be 4·9 magnitudes and the average residual ± $0^m{\cdot}77$. As the apparent magnitudes of 8 of the 40 nebulæ are marked in the Harvard catalogue as doubtful, I have considered it preferable to omit these nebulæ, and the results for the remaining 32 are given in the second part of the table. The rejection of the eight nebulæ alters Hubble's figures slightly, but it is to the values in the last column derived by employment of the Harvard nebular magnitudes that I would draw your attention. Those for the intermediate and late spirals are now in good accord, and in view of the small number of the irregular nebulæ the discordance of the value furnished by them cannot be considered very significant. The range is reduced to 2·1 magnitudes and the average residual to ± $0^m{\cdot}47$. These figures include, of course, besides the actual dispersions in the magnitudes of the nebulæ and of the stars, the errors in determining them, which in the case of the nebulæ may well amount to several tenths of a magnitude. The omission of the eight nebulæ with unreliable Harvard magnitudes, decided upon for *a priori*

reasons, receives justification from the fact that they provide the most discordant values of $m_s - m_n$. The revised figure of 8·4 for the difference in apparent magnitudes at once leads to a value for the mean absolute photographic magnitude of the nebulæ of −14·5. Hubble's value, which he derived by application of a colour index of +1·1, found from photovisual and photographic extra-focal measures, principally of nebulæ in the Virgo cluster, was −13·8. This change of $0^m.7$ involves an increase of 38 per cent. in Hubble's scale of distances, in so far as it depends on the magnitudes of the nebulæ.

I will now turn to the subject of the motions of the nebulæ. Some doubt has been expressed as to whether the red-shifts in their spectra should be interpreted as a Doppler effect, but in the absence of any satisfactory alternative explanation I consider that we are justified in expressing them in terms of velocity. The pioneer work on the radial velocities of the extra-galactic nebulæ was carried out by our Gold Medallist for this year. Not only was Dr. Slipher the first to measure and announce a velocity for one of these nebulæ, but he followed it up by observations on a number of others, and we owe to the Lowell Observatory the velocities of as many as forty of them. The work has since been extended to fainter objects by the observers on Mount Wilson with their more powerful equipment, and the general catalogue of radial velocities,* compiled by Dr. Moore and published last summer, contains results for ninety extra-galactic nebulæ.

Since it is generally admitted that the velocities of the nebulæ are subject to much less uncertainty than their distances, they do not call for so critical an examination, but I cannot refrain from a short description of the remarkable results now being obtained at Mount Wilson. By the employment of very rapid spectrographs Hubble and his colleagues have measured the velocities of nebulæ which are but little brighter than the faintest that can be detected by direct photography. Humason describes a spectrograph † which has the extremely small scale of 875 angstroms to the millimetre when used with one prism. Its objective is a lens designed specially for the purpose by Dr. Rayton with the short focal ratio of 0·6. Even with this spectrograph on the 100-inch reflector it is necessary to use very fast, and therefore coarse-grained, plates, and to expose for many hours. The whole length of the spectrum on the original negative is then only about two millimetres, so the obtaining of measurable lines, hazy as they are, must be regarded as a truly remarkable feat. The velocity of the cluster of nebulæ in Leo, as measured with this spectrograph, is estimated by the observer to be uncertain to the extent of 300 kilometres a second, which is, however, less than 2 per cent. of its value. When it has been possible to employ a spectrograph of larger dispersion, the uncertainty is considered to be not more than 100 kilometres a second. In the published reproductions of these nebular spectra only the H and K lines can be recognized, but on the original negatives the G band and $H\delta$ are usually to be found, and occasionally $H\beta$, $H\gamma$ and the iron line at 4383 A. These other lines serve to show that the

* *Lick Obs. Pub.*, **18**, 1932.

† *Ap J.*, **74**, 36, 1931.

shifts are proportional to the wave-lengths, *i.e.* that they conform to the conditions of a true Doppler effect.

The velocities as measured have to be corrected, of course, for the motion of the Sun relative to the nebulæ in general. In this I have followed de Sitter in adopting a value * which approximates closely to the motion of the Sun due to the rotation of the galaxy. It seems, indeed, that the peculiar velocity of our galaxy cannot be at all large. Omitting from Moore's catalogue three nebulæ whose velocities are marked as very uncertain, and the two companions of the Andromeda spiral, but with the addition of the Magellanic Clouds, we have 52 isolated objects and 32 nebulæ in 8 clusters, for which reliable distances and velocities are available. The distances of 7 of the isolated nebulæ are derived from Cepheids, and those of 13 more from the brightest stars in them. Of the rest, 24 depend for their distances upon the magnitudes in the Harvard catalogue and the 8 faintest nebulæ upon magnitudes determined extra-focally at Mount Wilson. A comparison between 15 nebulæ for which both Harvard and Mount Wilson photographic magnitudes were available showed that the latter were systematically fainter by $0^m{\cdot}2$. There did not seem, however, to be sufficient reason for thinking that a similar correction should be applied to the fainter Mount Wilson magnitudes, and they were therefore taken to be on the same scale as that of the Harvard catalogue.

TABLE IV

Velocities and Distances of the Extra-Galactic Nebulæ

Groups of Isolated Nebulæ

Distances (megaparsecs)	No. of Neb.	Mean Distance (megaparsecs)	Mean Velocity (k./s.)
0·03 to 0·48	8	0·26	138
0·60 ,, 0·91	9	0·76	438
0·96 ,, 1·15	8	1·06	761
1·32 ,, 1·58	8	1·44	855
1·66 ,, 2·09	7	1·78	1233
2·19 ,, 5·01	7	3·37	2076
5·75 ,, 10·00	5	7·50	4122

Clusters of Nebulæ

Constellation	No. of Neb. Measured	Distance (megaparsecs)	Velocity (k./s.)
Virgo	6	2·5	860
Pegasus	5	10·0	3850
Pisces	4	9·6	4760
Cancer	2	12·6	4940
Perseus	4	15·1	5380
Coma	8	19·0	7340
Ursa Major	1	29·5	11870
Leo	1	44·7	19640

* Viz. 286 k./s. towards $\alpha = 314°$, $\delta = +66°$.

In Table IV are given the mean distances and velocities for seven groups into which the isolated nebulæ have been divided and also for the eight clusters. The latter are apparently close aggregations of nebulæ, numbered in some cases by hundreds, and the assumption is made that they are no more extended in the line of sight than in their other two dimensions. The distance of each of the clusters has been derived from the most frequent apparent magnitude of its members, but the velocity depends on measures made upon one or more of the brighter objects in the cluster. The values of the velocity found for different members agree sufficiently well to justify the belief in a common motion for the whole cluster. It was pointed out by Hubble that with velocities of the order of 6000 kilometres a second and over the shift of the whole spectrum towards the red is large enough to affect the observed photographic magnitudes by sensible amounts. He consequently made suitable corrections to those of the three furthest clusters, amounting in the case of that in Leo to $0^{m}.25$, and the distances given in the table have been derived from the magnitudes so adjusted.

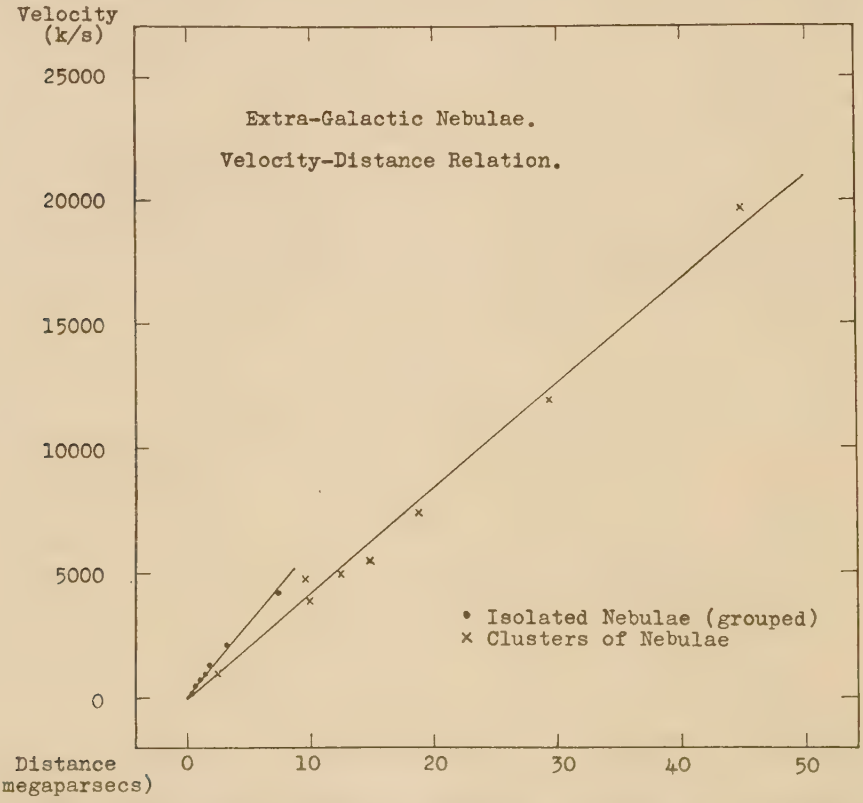
TABLE V

The Rate of Expansion (k./s./mp.)

Isolated Nebulæ	No.	Expansion Coefficient	
		Least Squares	H's Method
Distances from stars	20	573	582
Distances from mags. (up to 4·00 mp.)	24	614	601
Distances from mags. (beyond 4·00 mp.)	8	579	585
All Isolated Nebulæ	52	584	593
Clusters of Nebulæ	8	419	398

There are a number of ways of obtaining from these figures the rate of increase of velocity with distance, more conveniently referred to as the rate of expansion. I have tried several of them, and they all give results which are as accordant as can be expected from the nature of the material. In Table V the isolated nebulæ have been divided into three groups according as their distances depend on (*a*) the stars found in them, (*b*) Harvard magnitudes, or (*c*) Mount Wilson magnitudes, when they are too faint to be included in the Harvard catalogue. The results of solutions by least squares within these groups and for the clusters are given in the third column. The employment of this method with equal weight for each object has the effect of giving what may be considered as undue influence to the most remote members of the group, and so in the last column will be found the results of applying to the revised data the method used by Hubble, who correlated the magnitudes of the nebulæ with the logarithms of their velocities, and thereby possibly erred in the other direction. The results of the two methods are satisfactorily accordant, and the three groups of nebulæ will be seen to agree quite reasonably well amongst themselves, but there is a marked divergence between the values of the expansion coefficient found

for the isolated nebulæ and for the clusters. A similar difference was also inherent in Hubble's figures, but his method of treatment did not disclose the fact. His value for E, it will be recalled, was 560 kilometres a second per megaparsec, and was in effect that given by the clusters. I have adopted for present use the round figures of 590 and 400 for the isolated nebulæ and clusters respectively.



The diagram shows the results for the eight clusters and seven groups of isolated nebulæ, the straight lines being drawn for the values of the expansion coefficient given by the least squares solutions, namely, 419 and 584 kilometres a second per megaparsec. The picture does not refer to any one epoch, the distances and velocities being those possessed by the nebulæ at the several times when the light left them. In a universe where the velocity is a property of space, the linear relationship between velocity and distance should remain the same even in a diagram so constructed, for both increase uniformly with the time. But Professor Milne has pointed out to me that this is not the case in his "world," for the velocity there belongs to the nebula and does not increase with its distance. In consequence the velocity-distance relationship, if drawn as we have it here, should be in the form of a curve convex to the x-axis. Our present data are clearly insufficient to enable us to judge between the rival theories, but material for a crucial test does not seem altogether beyond our reach. The observers on Mount

Wilson have already measured the velocities of three clusters more remote than those dealt with here, though they have not yet announced detailed results, and we must not forget that with the 200-inch telescope they hope to be able to penetrate three times further into space than they can at present. In the meantime we have a problem nearer home, that presented by the two values found for the expansion coefficient. I will return to it later and will now proceed to discuss some further results with regard to the isolated nebulæ.

TABLE VI

Mean Absolute Magnitude of the Isolated Nebulæ

($M = m - 5 \log V + 5 \log E - 25$)

Type	No.	M
E	11	−14·5
Sa and SBa	10	−14·7
Sb	15	−14·8
Sc	5	−14·7
Irr	3	−14·0
All	44	−14·6

By adopting a value for the rate of expansion—I have taken E to be 590 in what follows—we can obtain from the velocity of each of the isolated nebulæ a distance which, when combined with the apparent magnitude, furnishes a value of the absolute magnitude. Table VI shows the resulting mean absolute magnitudes for the various nebular types. We have 44 nebulæ here as against the 32 for which absolute magnitudes have been already derived from the brightest stars in them, and they are largely different nebulæ, as only 14 of the former ones have measured velocities. What is more important is that two types of nebula, the elliptical and early spiral, are well represented here, although they were entirely absent from those in which stars had been found. The accordance between the first four types can be regarded, I think, as decidedly satisfactory, and the divergence shown by the irregular nebulæ again to be hardly significant in view of their small number. The luminosity function, or number of nebulæ within different intervals of absolute magnitude, is shown in Table VII. The

TABLE VII

Luminosity Function of the Isolated Nebulæ

Magnitudes	No. of Neb.
−12·5 to −12·9	0
−13·0 ,, −13·4	4
−13·5 ,, −13·9	4
−14·0 ,, −14·4	9
−14·5 ,, −14·9	12
−15·0 ,, −15·4	10
−15·5 ,, −15·9	5
−16·0 ,, −16·4	0

distribution is as smooth as can be expected for such a relatively small number. The total range is 2·9 magnitudes, rather greater than the value found before, viz. 2·1, but this is what one would naturally expect, since the dispersion in the velocities will have had some effect here, as also on the average residual, which has risen from $\pm 0^m.47$ to $\pm 0^m.59$.

I have also made an attempt to determine from the data the average peculiar velocity of the nebulæ. Taking the difference for each nebula between the observed velocity and that computed from the distance and the expansion coefficient, and grouping as before, the residual velocities will be found in Table VIII, expressed both as average values and as standard deviations. The latter can be considered as compounded of three parts, (*a*) the peculiar motion, which is taken to be the same for all distances, (*b*) the error in measuring the velocity, which can be assumed to increase slowly with the distance, and (*c*) the effect of the dispersion in absolute magnitude of the nebulæ, which increases in direct proportion to the distance.

TABLE VIII

Residual Velocities of the Isolated Nebulæ.

Distances (megaparsecs)	No.	$\overline{D}$ (mp.)	Residual Velocity		Effect of Scatter of $0^m.5$ in M_n (k./s.)
			Average (k./s.)	σ (k./s.)	
0·03 to 0·48	8	0·26	157	180	35
0·60 „ 0·91	9	0·76	163	201	105
0·96 „ 1·15	8	1·06	201	247	145
1·32 „ 1·51	6	1·39	210	234	190
1·58 „ 1·74	7	1·66	411	532	230
1·90 „ 4·17	7	2·51	421	504	345
5·01 „ 10·00	7	6·79	640	787	935

In theory it should be possible to determine these three quantities from the equations furnished by the seven groups, but actually I found the material too rough to yield results of any weight. We have other information, however, as to the value of two of the quantities ; the error of observation of a velocity can be gauged fairly accurately from the agreement between individual results and from the observers' estimates, and the dispersion in absolute magnitude of the nebulæ can be taken to be about $0^m.5$. The effect on the velocity of a magnitude-dispersion of this amount is given in the last column of the table. We are thus led to an approximate value of 140 kilometres a second for the average peculiar motion of the nebulæ.

We have, so far, proceeded on the assumption that there is no appreciable absorption of light in its passage to us from the nebulæ. The problem of the transparency of space is a very complicated one and is largely yet unsolved. It seems, however, that inter-galactic space can be given a clean bill of health ; the trouble must be looked for inside our galaxy. Shapley's researches on the globular clusters and on the colour indices of nebulæ in the Coma-Virgo region indicate no systematic absorption for rays oblique to the galactic plane, and yet there are reasons for suspecting a layer of

absorbing material closely concentrated towards the plane itself. That there is something of the kind along the periphery of the galaxy is shown without much doubt by the virtually total exclusion of the extra-galactic nebulæ from low latitudes, and it may well be that the "nucleus" of our system is hidden from view by obscuring clouds in Sagittarius, but the question that affects us at the moment is whether there is a layer of absorbing matter lying in the plane of the galaxy and involving the Sun. Such a layer as postulated by Trumpler has already been mentioned in relation to its effect on the zero of the Cepheid period-luminosity law. A uniform sheet of this kind would also clearly diminish the light from objects in all galactic latitudes, to an extent proportional to the cosecant of the latitude. In quite a recent paper in the *Astronomical Journal*,* van de Kamp has utilized the homogeneous material of the Harvard catalogue of nebulæ to make a further test of this hypothesis. The greater richness in nebulæ of the northern over the southern galactic hemisphere has been known for some time, but until the appearance of this new catalogue there was available no data sufficiently uniform for statistical use. Van de Kamp has now derived from the number of nebulæ down to the same magnitude, in different latitudes and in both hemispheres, a value of $0^m.8$ for the optical depth of the absorbing layer, and the position of the Sun as being about four-tenths of the way from the northern to the southern edge.

I thought it of interest to see what would be the effect on the relationship between the distances and velocities of the nebulæ of the introduction of van de Kamp's absorption. Apart from any correction to the absolute magnitudes of the Cepheids, his uniform layer of absorbing matter will not affect the distances of the nebulæ determined from stars, nor their mean absolute magnitude derived therefrom, but it will diminish the distances found from the apparent magnitudes of the nebulæ by amounts varying with the galactic latitude and with its sign. I found that the adoption of his hypothesis created havoc with the former consistency of the figures. It became clear that if there was any such uniform layer, its optical depth must have a much smaller value than $0^m.8$. So I attempted to determine a value of the absorption coefficient from the velocities and distances themselves, and found it to be, if I may use a phrase which is more expressive than scientific, nought to several places of decimals. It must be remembered that van de Kamp's result is derived from a much larger volume of material than is here represented, but the nebulæ whose velocities have been measured are well distributed in galactic latitude, and it does not seem possible to reconcile our present data with the hypothesis that the Sun is situated in a uniform absorbing layer of more than quite small optical depth. It is likely, however, that irregular absorption exists, especially in low latitudes, and it is perhaps significant in this connection that the four nebulæ † with the largest negative residual velocities are all within 30° of the galactic plane, and that they tend to appear large for their magnitudes. If we had to classify our galaxy, we should, I suppose, put it down as a late spiral or possibly as

* *A.J.*, 42, 97, 1932.

† *N.G.C.*, 404, is the most conspicuous example.

an irregular nebula, and our experience of these types suggests that the absorbing material in them is more likely to be distributed in an irregular manner than as a uniform band, such as is found in the early types. Until we know a good deal more about the incidence of absorption, and can make allowance for it, we must expect a certain number of nebulæ to show what are apparently discordant results.

In general, however, the isolated nebulæ may be looked upon as being members of a remarkably well-behaved family. Irrespective of type they are seen to conform to a standard luminosity about which the dispersion, as now determined, is far from large. Our present data must, moreover, be considered as provisional in nature, and in view of the difficulty in determining the magnitudes of the nebulæ, not to mention their velocities, and of the disturbing effect of absorption, I think it not unlikely that, when more and better material is available, we shall find that the dispersion is even smaller than it now appears to be.

The only large divergence from uniformity, for which we have yet to seek an explanation, is the difference in the rates of expansion found for the isolated and cluster nebulæ. It seems unlikely that these two classes of object are really receding from us with velocities that are different functions of their distances. It is more reasonable to suppose that the discrepancy is due to error in the assumption of the same mean magnitude for the nebulæ in the clusters as for the isolated objects with which we have been dealing. The two values of the expansion coefficient can be reconciled by supposing that the cluster nebulæ are in the mean $0^{m}.9$ fainter than the isolated nebulæ. We can look on this in two ways, by supposing either that the particular isolated nebulæ from which the mean absolute magnitude was determined are brighter than the general average of their kind, or that the members of the clusters are actually of smaller luminosity than the isolated nebulæ in general. Let us examine these two possibilities in turn. We must always be on guard against the insiduous influence of selection, but it is difficult to see how we can put the blame for much of the effect now found on to this old enemy of the astronomer. Doubtless he will have done his best to contrive that the nebulæ whose velocities have been measured have been intrinsically brighter, rather than fainter, than the average, but the mean absolute magnitude has been derived from those nebulæ in which stars have been found, and there seems no particular reason to suppose that detection of stars would be facilitated by high luminosity in the nebula. Hubble has, moreover, given us for thirty nebulæ, of a similar kind to those in which he found stars but in which he had searched for them in vain, upper limits for the apparent brightness of such stars as may exist. It follows that the mean absolute magnitude of these particular nebulæ is brighter than -14.4, *i.e.* they are at least as bright as those in which stars were found. Thus, I can see no evidence in support of the assumption that the isolated nebulæ upon which the adopted value of the mean absolute magnitude depends are other than typical as regards luminosity.

To turn to the second alternative ; the reasons for supposing that the cluster nebulæ are essentially of the same kind as those found as scattered

units have been a general similarity in appearance, colour index and range in luminosity. Hubble found the last to amount to five magnitudes in each case, but the revised figures have brought about a considerable reduction in that of the isolated nebulæ. The dispersion in the clusters, however, cannot be reduced, unless we cease to regard them as compact masses, and assume also a dispersion in distance. That a cluster would in time become elongated in the direction of its motion seems a not unlikely possibility, if its members may be regarded as moving with simple velocities in an Euclidean space, but whether in an universe under the iron rule of Relativity such behaviour would be tolerated I do not feel at all sure. In any case, to ascribe a range of two apparent magnitudes to dispersion in distance alone is to stretch the hypothesis and the cluster rather more than they will probably stand. It would, however, be of interest to know whether the apparently fainter members of the clusters have the same velocities as the brighter, which alone, as far as I am aware, have yet been measured. What direct evidence there is as to the absolute magnitude of cluster nebulæ certainly suggests that they are fainter than their isolated brothers. There are eleven nebulæ in the Virgo cluster in which Hubble has detected stars, and although they are among the apparently brighter members of the cluster their mean absolute magnitude is given by the stars to be $-14{\cdot}0$, *i.e.* half a magnitude fainter than the value we have adopted for the isolated nebulæ.

If this story has a moral, it is plainly that we need a much greater body of observational material. Not until the measured velocities are numbered by hundreds, or even thousands—and for this we do not require any larger telescopes than we now possess—and until a good deal more work has been done on the subject of nebular magnitudes, will the practical astronomer be in a position to tell the mathematician what exactly his theories are required to explain. And I think it would not be improper in this room to express the hope that British astronomy, to which we owe so much of the pioneer work on the nebulæ—I need but mention the names of Herschel, Lassell, Rosse and Isaac Roberts—may some day be able once again to play its part in contributing to this most fascinating branch of our science.

ELECTION OF OFFICERS AND COUNCIL

The following Fellows were elected as Officers and Council for the ensuing year :—

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E. A. Milne, Esq., M.B.E., M.A., D.Sc., M.Sc., F.R.S., Rouse Ball Professor of Mathematics, Oxford.

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H. H. Plaskett, Esq., M.A., Savilian Professor of Astronomy, Oxford.

R. O. Redman, Esq., M.A., Ph.D., Assistant Director, Solar Physics Observatory, Cambridge.

R. Stoneley, Esq., M.A., Sc.D.

Sir G. T. Walker, C.S.I., M.A., Sc.D., F.R.S., Professor of Meteorology, Imperial College of Science and Technology, South Kensington.